MARKET STRUCTURES, STRATEGIC INVESTMENT BEHAVIOR, AND PROFITABILITY

BY

VIVEK GHOSAL

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I dedicate this dissertation to my parents.

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Recent models of oligopoly theory have shown that an incumbent firm, by making a strategic investment commitment in the pre-entry stage, may deter entry. My key hypothesis is that adjustment costs of capital will influence an incumbent firm's decision to install strategic capacity. By assuming a quadratic and symmetric adjustment cost function, I looked at the issues related to the credibility and desirability of strategic investment. I hypothesised that only over an intermediate range of adjustment costs of capital will the incumbent firm have an incentive to install strategic capacity. From this I derived an inverted U-shaped relationship between adjustment costs of capital and seller concentration. A cross section study across 125 S.I.C. 3-

digit manufacturing industries provided evidence in favor of this relationship.

Studies on the relationship between concentration and profitability have recently highlighted the intertemporal instability of this relationship. Adopting a methodology by which we carry out cross section analysis after controlling for cyclical fluctuations, I failed to find any structural instability in the relationship. Using a correct non-linear specification, I show that elasticities between concentration and profitability have remained remarkably stable over the period 1968-1977. My results show that concentration and profitability are positively related only at higher concentration levels. Also, the results show strong evidence in favor of a negative relationship between unionism and profitability, and that this negative effect is to be found primarily in more oligopolistic industries. My analysis shows that model specification is an important issue in analyzing the structure-performance relationship.

To formally analyze the behavior of industry price-cost margins over business cycles, I looked at the influence of monetary base expansion on price-cost margins. I found that the relationship between growth rate of monetary base and price-cost margins was positive. Furthermore, I found that more concentrated industries showed stronger pro-cyclical margins.

CHAPTER I
INTRODUCTION

The structure-conduct-performance paradigm has been an important framework of analysis in industrial organization. In this framework an important component of structure is the number and size distribution of firms. Conduct, or firm behavior, is assumed to depend on market structure. Conduct, in the form of pricing strategies and pre-emptive behavior, in turn influences profitability, or performance, of firms. The theoretical and empirical works on the determinants of market structures initially concentrated on technological characteristics, fixed costs, demand growth, and some measure of entry barriers, created or natural, as the key determinants of the size distribution of firms in an industry. Subsequent works analyzed and tested the role of advertizing intensity, research and development intensity as being artificially created barriers to entry in concentrated markets. More recent theoretical work has concentrated on the role of pricing strategies and investment behavior within a game theoretic framework as important aspects of firm behavior. See Scherer (1980), Stiglitz and Mathewson (1986), and Waterson (1984) for an overview of this literature. Empirical work has been voluminous and often inconclusive. See Curry and George (1983) for a survey of the empirical literature on the determinants of concentration.

Seller concentration, as measured by four-firm concentration ratio (CR4), is generally regarded as an important determinant of business behavior and industry performance. In the study of seller concentration and performance there are two fundamental, and distinct, questions that need to be analyzed: (1) What determines the level of seller concentration? (2) What are the potential effects of market power? We analyze both these questions. In chapter II we focus on the determinants of seller concentration in light of the new theories of industrial organization and firm behavior (Dixit 1979, 1980, 1982; Eaton and Lipsey 1979, 1981; Spence 1977, 1979; and Spulber 1981). The idea in these models is that firm behavior may be an important determinant of seller concentration. To the extent that entry is one of the determinants of seller concentration, entry deterring behavior will influence market structures. I use the broad framework of the above mentioned models to analyze strategic investment behavior and its influence on seller concentration.

I identify parameters that will influence a firm's decision making with regard to installing strategic capacity. The theoretical models by Dixit, Spence, and Spulber ignore the implications of adjustment costs of capital on a firm's strategic behavior. My key hypothesis is that adjustment costs of capital will influence an incumbent firm's decision to install strategic capacity. If the costs

of adjusting capital upward are high, strategic capacity would be costly to install. If costs of downward adjustment are low, strategic capacity will not serve as an irreversible commitment. It is only over an intermediate range of adjustment costs of capital that the incumbent firm will have an incentive to install strategic capacity.

Although theoretically demand growth is predicted to be an important determinant of market structures, the empirical literature has provided inconclusive evidence. Depending on the sample period and level of aggregation, studies have shown that demand growth may increase or decrease seller concentration. In chapter II I present the various arguments related to demand growth and its relationship to seller concentration, and note that only in the absence of pre-emptive behavior will demand growth reduce seller concentration. The literature has been less rigorous in analyzing the role of demand uncertainty on seller concentration. Assuming risk-aversion on part of the potential entrant, demand uncertainty may lead to lesser entry. This would imply a positive relationship between seller concentration and demand uncertainty. I examine this empirically.

The literature on the relationship between concentration and profitability has consistently provided evidence in favor of a positive relationship. The literature assumes a monotonic relationship between concentration and

profitability. Without exception, all early studies were cross section studies. Recent works by Qualls (1979) and Domowitz et al. (1986a, 1986b) showed that price-cost margins show cyclical patterns, and that these patterns vary across levels of concentration. Domowitz et al. show that cross section results are misleading, because of the cyclical nature of price-cost margins (PCM). In chapter III we carry out a cross section analysis after controlling for cyclical fluctuations. I show that the evidence presented by Domowitz et al. (1986a) can be misleading. Controlling for cyclical variability and using a correct non-linear specification I show that the elasticities between concentration and profitability have remained remarkably stable over the period 1968-1977.

I also focus on the issue of unionization and its effects on profitability. I shall show that the significance of the unionism effect is dependent on model specification, and that there is strong evidence of the unionism effect being found primarily in more oligopolistic markets.

Regarding the analysis of the cyclical nature of PCM, Qualls (1979) analyzed the volatility of PCM for 79 4-digit industries and concluded that the cyclical variability of PCM was positively related to concentration. Domowitz et al. (1986a) using the economy wide unemployment rate as an indicator of aggregate demand, showed that PCM were strongly pro-cyclical in more concentrated industries. Their results,

curiously enough, suggest that PCM is counter-cyclical in less concentrated industries. Schmalensee (1987) points out that the secular increase in the unemployment rate over the period 1958-1981 reflects structural changes in the labor market rather than a trend towards increasing slack in the markets. Therefore, he concludes that the unemployment rate is a bad indicator of aggregate demand. He found the capacity utilization rate to be a better indicator of aggregate demand.

To analyze the behavior of PCM over business cycles I considered growth rate of the monetary base as an aggregate demand influence (in contrast to aggregate demand indicators used by Domowitz et al. (1986a) and Schmalensee). Increase in growth of the monetary base will cause an expansion of demand. Decrease in the growth rate will cause a downturn. I used current and lagged growth rates of the monetary base to study PCM movements over business cycles.

CHAPTER II
ADJUSTMENT COSTS OF CAPITAL, PRE-EMPTIVE INVESTMENTS, AND SELLER CONCENTRATION

Capacity as an Entry Deterring Instrument

Schelling (1960) argued that a threat, which is costly to carry out, can be made credible by entering into prior commitment. Recent models of oligopoly theory show that an incumbent firm, by making an investment commitment in the pre-entry stage, can change the initial conditions such that it may alter the post-entry outcome in its favor. Dixit (1980), using linear demand and cost functions, shows that if the post-entry game is Nash then firms, by investing in strategic capacity, may deter entry. In Dixit's model firms will not hold any idle capacity. Spulber (1981), in a more general and dynamic model, shows that firms may install strategic capacity under both Nash and Stackelberg strategies. Under a Nash strategy there will be no idle capacity whereas under a Stackelberg strategy, firms may hold idle capacity. Dixit (1979) and Spence (1977) show that if the post-entry game is Stackelberg, firms will hold idle capacity and the threat is one of expanding output in the face of entry. A Cournot-Nash strategy results in a constant high output whereas a Stackelberg strategy is one of underutilized capacity in the pre-entry stage.

The basic idea behind the models can be explained

with the following three figures. Figure 2.1 examines the marginal cost and marginal revenue functions for the established firm, and in Figure 2.2 we get the established firm's reaction function. Figure 2.3 shows the equilibrium output levels for the entrant and the established firm under different reaction functions for the incumbent.

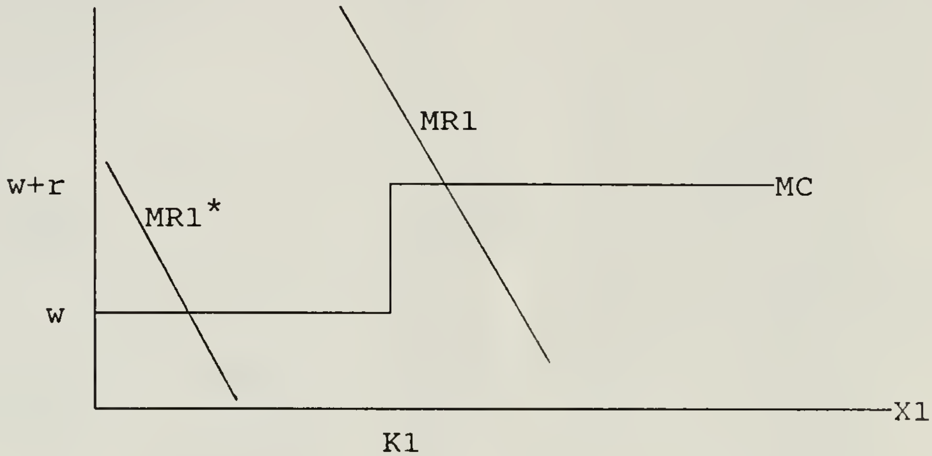

Figure 2.1: Marginal Cost and Marginal Revenue

In figure 2.1, MC is the established firms marginal cost schedule. The variable costs associated with labor are constant at w, and capacity expansion costs equal r. For capacity choice K1, marginal costs are w till K1. Beyond K1 capacity expansion costs matter, so marginal costs are w+r. Let MR1 be the established firm's marginal revenue schedule when its rival produces no output. An increase in the rivals' output will shift the established firms marginal revenue schedule to the left e.g. from MR1 to MR1*.

By tracing the movement of the intersection of the marginal revenue schedule with the marginal cost schedule we get the established firm's reaction function given in figure 2.2. We get a vertical stretch in the reaction function corresponding to the vertical stretch in the marginal cost schedule in figure 2.1.

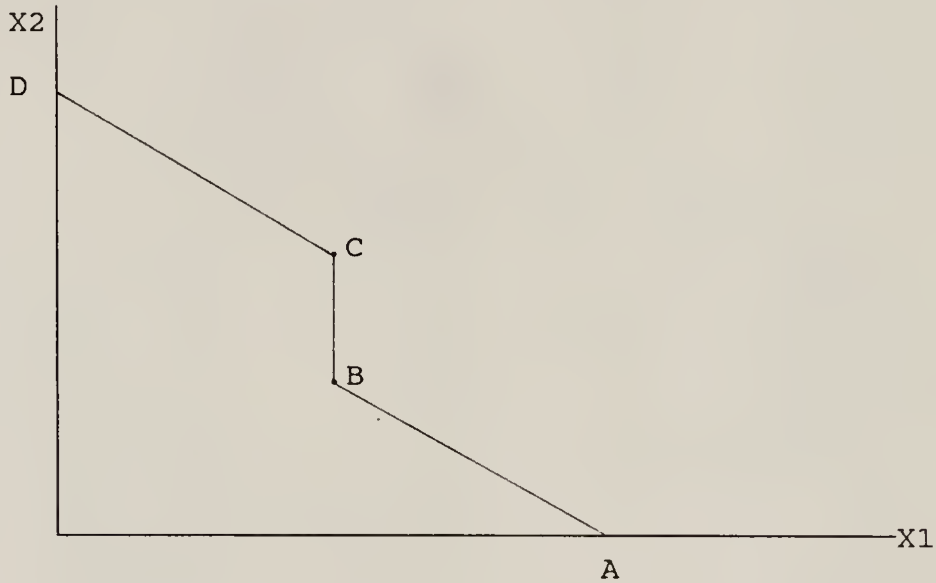

Figure 2.2: Established Firm's Reaction Function

In figure 2.2, X1 is the established firm's output and X2 is the entrant's output. Stretch AB represents the capacity constrained stretch and CD is the stretch where capacity is not a constraint. If the established firm chooses to install a larger level of capacity, then the established firm will have a longer stretch of the unconstrained reaction function. Thus by choice of capacity in the pre-entry stage, the

established firm can present either the capacity constrained reaction function, R1(C), or a reaction function where capacity is not a constraint, R1(UNC). In figure 2.3, the entrant's reaction function is R2. So if the established firm presents R1(C), then the entrants output is $X2^1$. If the established firm presents R1(UNC), then the entrants output is $X2^2$. So by choosing a larger capacity in the pre-entry stage, the established firm forces the entrant to smaller levels of output. If the residual demand for the entrant becomes so small that it does not make any positive profits, then entry will be deterred.

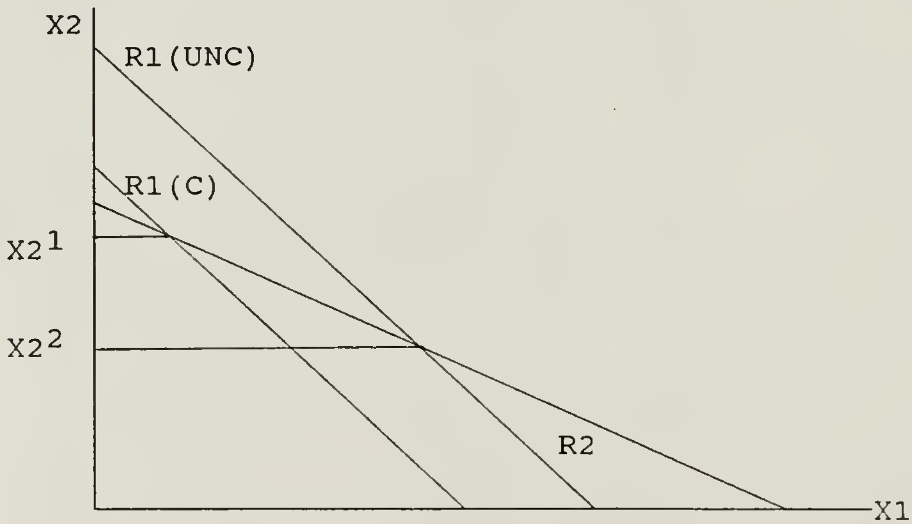

Figure 2.3: Equilibrium Output

In the oligopoly models that we referred to above, investment in capacity serves as the entry-deterring

instrument. One of the main assumptions of these models is that capital is industry specific. Therefore these models assume that there is no downward adjustment of capacity. Also, they assume that there is an instantaneous upward adjustment of capacity.

Under the assumption of no downward adjustment of capacity, installed capacity always represents an irreversible commitment. The requirement of credibility is automatically satisfied. Instantaneous upward adjustment of capacity implies that there are no costs associated with adjusting capacity upwards to entry deterring levels.

Adjustment Costs of Capital and Seller Concentration

In this paper I consider an environment where firms can adjust capacity, subject to adjustment costs. I hypothesize that adjustment costs of capital will influence an incumbent firm's decision to install strategic capacity. Adjustment costs will determine whether the installed capacity represents an irreversible commitment. Also, adjustment costs of capital will contribute to the total cost of installing new capacity. High adjustment costs of capital would imply that incumbent firms have little incentive to install strategic capacity. Gould (1968) and Mussa (1977), among others, have analyzed the issues related to the adjustment costs of capital. Two reasons are given as to why firms would incur adjustment costs of capital: (i) for upward

adjustment of capital there are costs associated with integrating new capital, training workers etc. (ii) for downward adjustment of capital, the firm has to devote resources for dismantling and removing capital, and reorganizing production schedules. Holt et al. (1960) provide a suggestive list of adjustment costs that might be incurred and provide justification for using quadratic cost functions. Following the standard approach in literature, I assume that adjustment costs are <u>quadratic</u> and <u>symmetric</u> in upward and downward adjustment.

If entry deterrence is profitable, the following inequality must hold.

$$P(m) - C > P(d) \tag{2.1}$$

where P(m) and P(d) are monopoly and doupoly profits, respectively. The cost of deterring entry is C. Adjustment costs of capital will be one of the components of C. Strategic capacity must (i) be installed prior to entry and (ii) represent an irreversible commitment (see Dixit (1982)).

Adjustment costs of capital will determine whether installed capacity represents an irreversible commitment. If costs of adjusting capacity are low, firms could, fairly costlessly, adjust capacity downwards. Therefore the irreversibility condition will not be satisfied. The irreversibility condition will be satisfied only over a

higher range of adjustment costs of capital. The magnitude of C in inequality 2.1, combined with the irreversibility condition, will determine whether the incumbent firm has an incentive to install strategic capacity.

We use figure 2.4 to construct a simple framework within which we analyze the nature of the relationship between adjustment cost of capital, strategic investment behavior, and seller concentration. In figure 2.4 let K(ED) be the entry deterring level of capital stock and K(M) be the monopoly level of capital stock. Strategic capacity is given by K(ED)-K(M).

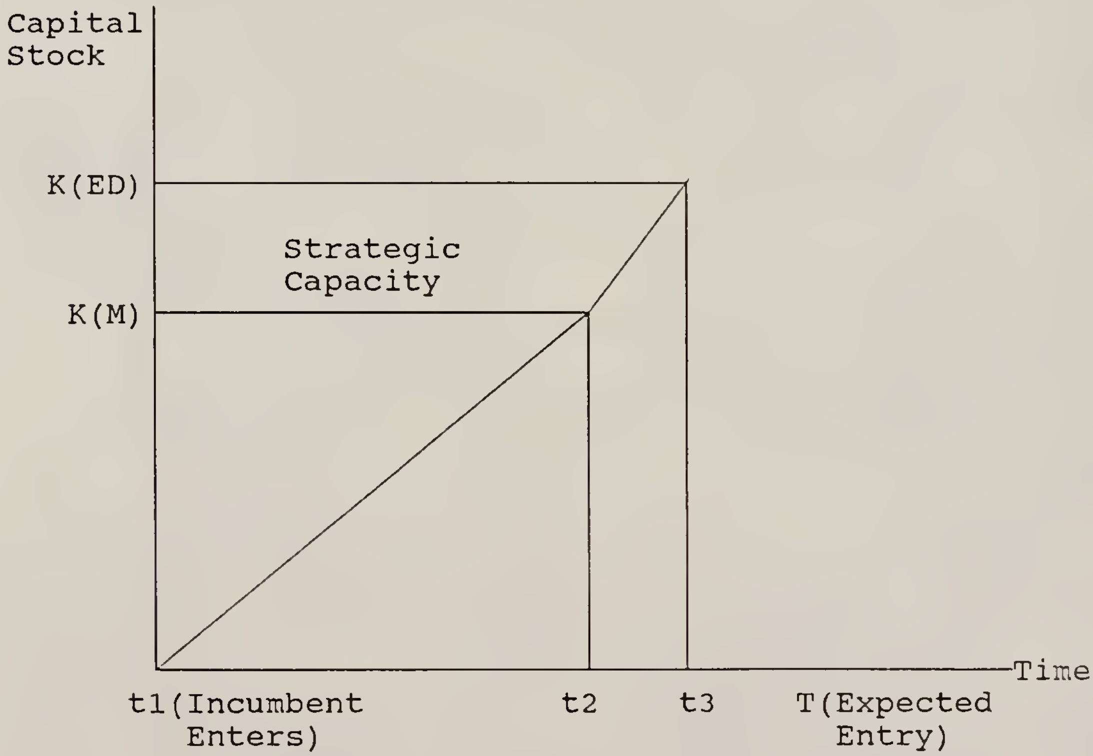

Figure 2.4: Strategic Capacity

The established firm enters the industry in period t1. By period t2 it has installed its monopoly level of capital stock, K(M). If the established firm expects entry at some time period T and it wants to install strategic capacity, it must do so before period T (say by period t3, where the distance between t3 and T can be arbitrarily small).

The irreversibility of the commitment of installing strategic capacity, K(ED)-K(M), will be determined by the costs of adjusting capacity--CK for short. I had earlier mentioned that adjustment costs are symmetric. This implies that costs of upward and downward adjustment are the same i.e. CK. A high cost of adjusting capacity downward would imply that the commitment _is_ irreversible. However, a high CK would lead to P(m) - C < P(d). This implies that sharing is the best strategy and the incumbent firm will have no incentive to install strategic capacity.

If CK is low, then P(m) - C > P(d) but strategic capacity will _not_ serve as an irreversible commitment. A low CK implies that the incumbent firm could, fairly costlessly, adjust capacity downwards. The entrant will not perceive installed strategic capacity as a threat and the incumbent will have no incentive to install it.

Over the intermediate range of CK we may have adjustment costs high enough for strategic capacity to serve as a near-irreversible commitment. At the same time we have

CK not high enough to reverse the inequality 2.1. It is over this intermediate range of CK that the incumbent firm will have an incentive to demonstrate entry deterring behavior by installing strategic capacity. There are two counteracting forces of <u>credibility</u> and <u>desirability</u>. Credibility is an increasing function of CK and desirability is a decreasing function of CK. Figures 2.5 and 2.6 show the relationships.

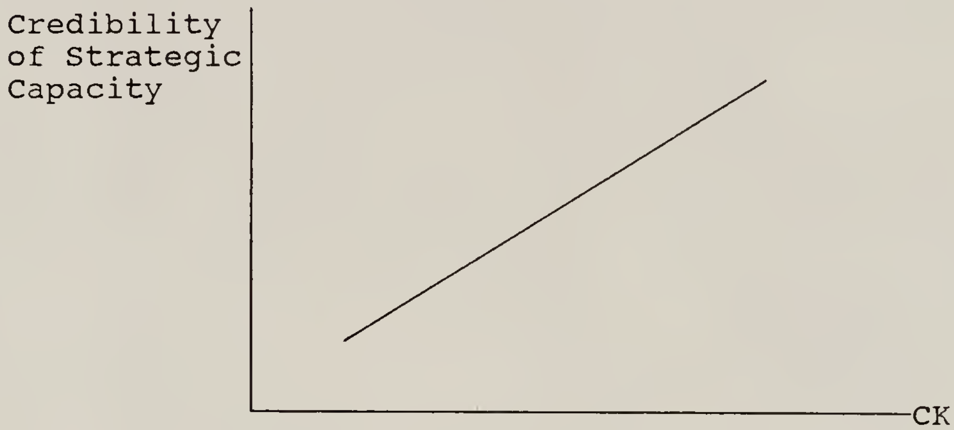

Figure 2.5: Credibility of Strategic Capacity

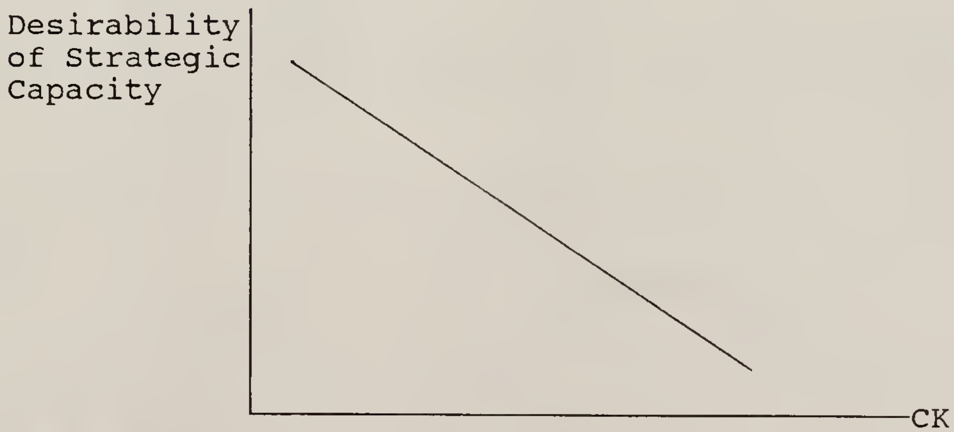

Figure 2.6: Desirability of Strategic Capacity

The two counteracting influences of credibility and desirability determine the <u>likelihood of strategic investment</u>. The likelihood is low, over low and high values of CK. The likelihood is high over the intermediate range of CK. For symmetric adjustment costs, the relationship is shown in figure 2.7.

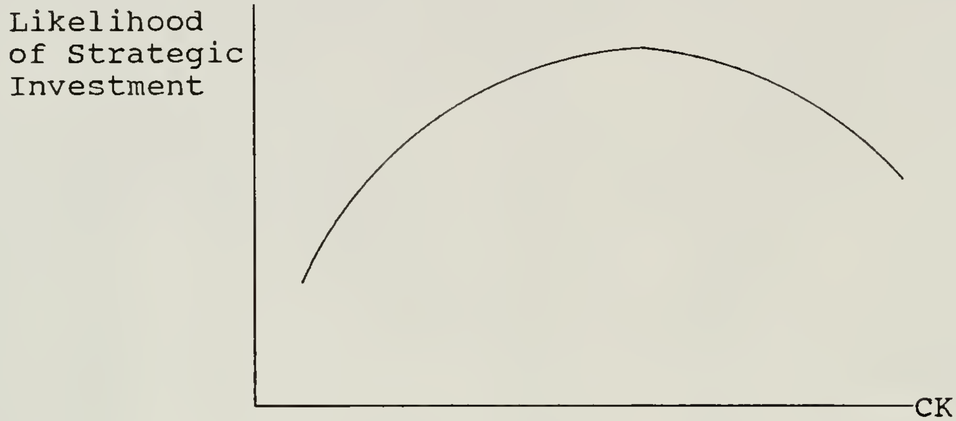

Figure 2.7: Likelihood of Strategic Investment

The relationship as it stands above cannot be tested because we do not have a measure of likelihood of strategic investment. To make the relationship testable we use the concept of <u>barriers to entry</u>. Barriers to entry are high when likelihood of strategic investment is high. Low and high values of CK, implying low likelihood of strategic investment, give us low barriers to entry. Relating <u>market structures</u> to barriers to entry, we get high seller concentration when barriers are high. When barriers are low, we get low seller concentration. So the relationship between

seller concentration, and capacity adjustment costs is an inverted U-shaped. Low and high CK imply low concentration. Intermediate values of CK imply high concentration. Equation 2.2, table 2.1, and figure 2.8 summarize the relationship between seller concentration (CR4) and cost of adjusting capacity (CK).

$$CR4 = f_1(\underset{+}{CK} : \underset{-}{CK^2}) \qquad (2.2)$$

Table 2.1
Strategic Investment and Seller Concentration

CK	Strategic Investment	Barriers to Entry	Concentration
Low	Unlikely	Low	Low
Intermediate	Likely	High	High
High	Unlikely	Low	Low

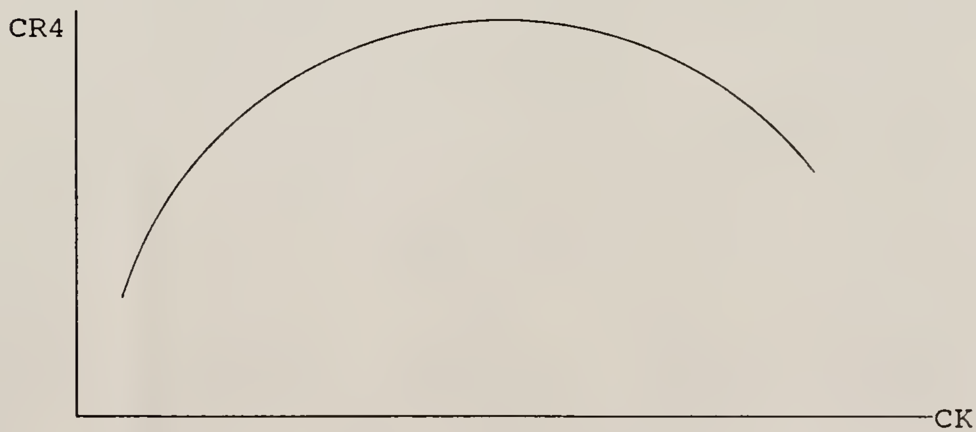

Figure 2.8: Adjustment Costs of Capital and Concentration

Demand Conditions and Capital Intensity

Nakao (1980), in a model of demand growth and entry, shows that a high rate of growth of demand will raise the rate of return on capital and lower entry barriers. High demand growth, by attracting entry, will lower the established firms market share. Spence (1979), in a model of investment strategy in growing markets, argues that just as potential entrants may be deterred by the capacity that the established firms have installed, smaller firms may be deterred from expanding by the existing capacity of their larger rivals. Eaton and Lipsey (1979) show that a monopolist could pre-empt the market by installing new capacity just before a new entrant decides to do so.

The growth model of Nakao and the strategic investment models have different predictions on the growth-concentration relationship. If strategic investment succeeds in deterring rivals from entering or expanding, then demand growth will not reduce seller concentration. High rates of growth will reduce the leader firm's ability to pre-empt, but the theory does not provide us with any priors as to how high the rate of growth should be. Demand growth will be negatively related to concentration only if the growth influences dominate.

The second aspect of demand we consider is demand volatility (DV). Models of the firm that analyze decision making under demand uncertainty typically assume risk-

aversion (see Leland (1972)). If expected profit equals certainty profit, then, under risk-aversion, the expected utility of profits is lower under uncertainty than under certainty. Looking at it from the entrant's perspective, a risk-averse entrant is less likely to enter an industry with high demand uncertainty (see Sandmo (1971)). Thus industries with high demand uncertainty may attract less entry and therefore be more concentrated. The relationship between concentration and uncertainty is likely to be positive.

Lastly we look at the capital-labor ratio. It has been argued that a high capital-labor ratio (K/L) might imply high barriers to entry. Therefore K/L and concentration are likely to be positively related. Some of the recent literature on contestable markets (see Baumol, Panzar, and Willig (1980)) has stressed on sunk cost as the true barrier to entry. But since we do not have a measure of sunk cost, we use K/L as our measure of entry barrier. Equation 2.3 gives us our relationships from this section.

$$CR4 = f_2(\underset{?}{DG} : \underset{+}{DV} : \underset{+}{K/L}) \tag{2.3}$$

Combining equation 2.2 and 2.3 we get the determinants of seller concentration as analyzed in sections 2 and 3 of this chapter:

$$CR4 = f_3(\underset{+}{CK} : \underset{-}{CK^2} : \underset{?}{DG} : \underset{+}{DV} : \underset{+}{K/L}) \tag{2.4}$$

In equation 2.4, CK and CK^2 are the variables that capture the behavioral aspects of the relationship. Demand growth (DG) and demand volatility (DV) capture the market demand conditions. In the next section we outline a procedure and estimate adjustment costs of capital which are required to test the relationship 2.4.

Estimation of Adjustment Costs of Capital

In section 2 we noted studies by Gould (1968) and Holt et al. (1960) which have analyzed the various components of adjustment costs of capital and the justification for using quadratic and symmetric adjustment cost functions. In this section we obtain a measure of adjustment costs of capital (CK), within a partial adjustment framework. Partial adjustment models, which have their basis in quadratic cost minimization, along with various expectations schemes, have been widely used to analyze factor adjustment processes. Techniques that enable us to directly estimate adjustment costs are computationally expensive and, more importantly, beset with estimation problems (see Appendix A).

I adopt a framework of partial adjustment under rational expectations to estimate the speed of adjusting capital (see Kennan (1979)). I then use the estimated speed of adjustment as a proxy for cost of adjustment. If the estimated speed of adjustment is low (high) then the cost of adjustment is taken to be high (low). Kennan's model is

estimated by ordinary least squares and is ideally suited for our highly disaggregated study. While Kennan uses his framework to study labor adjustment, I use the model to estimate speeds of adjusting capital.

The firm is assumed to be making decisions on the optimal choice of capital stock such that it minimizes the expected present value of a quadratic loss function:

$$\min_K E\, \Sigma_t R^t \{ a_1(K_t - K^*_t)^2 + a_2(K_t - K_{t-1})^2 \} \tag{2.5}$$

where R is the known discount factor (following Kennan we assume R=1). Capital stock in time period t, is K_t. The stochastic target level of capital stock is K^*_t. The target level is related to output, which is the observed exogenous variable. It can be shown from 2.5 that the optimal path for capital follows the partial adjustment rule (see Kennan, p. 1443):

$$K_t - K_{t-1} = \delta(d_t - K_{t-1}) \tag{2.6}$$

where δ is the speed of adjustment of capital, and d_t is the long run target level of capital stock. The optimal decision rule is given by equation 2.7.

$$K_t = (1-\delta)K_{t-1} + \delta d_t + e_t \tag{2.7}$$

Assuming rational expectations, Kennan shows that if output follows an autoregressive process of order p, AR(p), then the long run target, d_t, can be replaced by a linear combination of current and past values of output.

We have 125 S.I.C. 3-digit manufacturing industries in our sample. Annual data on output were obtained from the Bureau of Industrial Economics data base. Regressions of output on lags of output showed that for the majority of industries one lag of output was significant in determining current output. So for convenience we assume an AR(1) process, for output, for all the industries in our sample. Therefore in equation 2.7 we replace d_t by current and one lag of output. Our estimating equation is

$$K_t = \beta_1 K_{t-1} + \beta_2 Q_t + \beta_3 Q_{t-1} + u_t \tag{2.8}$$

where $\beta_1 = (1-\delta)$ and $0 < \delta < 1$. As noted earlier, δ is the speed of adjusting capital. So β_1 is our proxy for adjustment costs of capital (CK) and $0 < \beta_1 < 1$. Adjustment costs are negligible (very high) if β_1 is close to zero (unity).

Along with output (Q), annual data on gross capital stocks (K) were obtained from the B.I.E. data base. We have 125 3-digit industries in our sample. All data were measured in constant (1972=100) dollars. The annual time series is for the period <u>1958-1980</u>. Before we estimate equation 2.8, all data were converted to logarithms and then first differenced.

Differencing is done to induce stationarity (see Fuller (1976)). Also, in time series data, a common trend among explainatory variables is a source of multicollinearity. Differencing is one of the methods suggested to correct for this problem (see Maddala (1977)). We estimate equation 2.8 for the 125 industries in the sample.

All our estimates of β_1 are within the parameter bounds. The mean β_1 is 0.76 with a standard deviation of 0.18. A high mean β_1 is indicative of the fact that there are high costs of adjusting capital over an annual horizon. Some of the industries with relatively high adjustment costs are industrial organic chemicals, reclaimed rubber, iron and steel foundries, electrical industrial apparatus, meat products, communication equipment, and railroad equipment (the corresponding S.I.C. 3-digit codes are 286, 303, 332, 362, 201, 366, and 374). Some of the industries with relatively low adjustment costs are weaving mills-manmade fibres, pulp mills, leather goods, cut stone and stone products, plumbing and heating (non-electrical), optical instruments and lenses, and concrete, gypsum, and plaster products (the 3-digit codes are 222, 261, 319, 328, 343, 383, and 327).

Empirical Analysis

The model to be estimated as derived in section 2 is

$$CR4 = \alpha_0 + \alpha_1 CK + \alpha_2 CK^2 + \alpha_3 K/L + \alpha_4 DG + \alpha_5 DV + v_t \qquad (2.9)$$

where

CR4	is the 3-digit four firm seller concentration
CK	is the cost of adjusting capacity
K/L	is the industry capital-labor ratio
DG	is the rate of growth of industry output
DV	is the measure of demand uncertainty.

As regards sign prediction, α_1, α_3, $\alpha_5 > 0$ and $\alpha_2 < 0$. The sign of α_4 is ambiguous.

Data on production workers (L) were obtained from the B.I.E. data base. Data on unadjusted concentration ratio (CR4) were obtained, at the 4-digit level, from the census of manufactures. I compute 3-digit concentration ratios as a weighted (by shipments) average of 4-digit concentration ratios. Weiss and Pascoe (1986) <u>adjust</u> the census concentration ratios for geographical fragmentation of markets, disclosure problems, and import competition. To estimate equation 2.9 I constructed two samples. <u>Sample 1</u> covers the period <u>1958-1972</u>. Since output follows a time trend, computing the coefficient of variation will not give us a proper measure of demand volatility. Instead we regress:

$$LogQ = a_0 + a_1 t + \epsilon_t \qquad (2.10)$$

where LogQ is the logarithm of output and t is time. We use the standard deviation of the residuals from this regression as our measure of demand volatility (DV). The average annual

rate of growth was obtained by continuous compounding over the sample period. So, from the output time series we get DG(1) and DV(1). The numbers in parentheses reflect the sample period. Capital-labor ratio, K/L(1), is the mean ratio over the sample period. The census concentration ratio for the first sample, CR4(72), is for the year 1972. The adjusted ratio is ACR4(72).

Sample 2 covers a slightly longer sample period 1958-1977. All variables are constructed in the same manner as in sample 1. So we have DG(2), DV(2), and K/L(2) as our constructed variables. The adjusted concentration ratio for the year 1977 is ACR4(77).

We only have one set of estimates for CK, as obtained in the previous section. The lack of a longer time series in K and Q has prevented us from estimating different sets of CK. Seller concentration at any point in time must to some extent reflect past influence of firm behavior, demand growth, and demand volatility. It is for this reason that we use a sufficiently long time period to construct our variables.

Next we present the results of estimating equation 2.9. Since theory does not provide us with any functional forms, researchers have used both the levels and a logarithmic form to estimate the relationships (see Curry and George (1983), and Waterson (1984, cp 10)). Our logarithmic form uses logarithms of concentration and capital-labor ratio

denoted by LCR4(72) and LK/L, respectively. Means of the variables and estimates, for samples 1 and 2, are presented in tables 2.2-2.5.

The t-statistics are in parenthesis. All t-statistics are computed from heteroskedasticity-consistent standard errors (see White (1980)). Examining the coefficients in tables 2.3 and 2.5 we observe that all the coefficients attatched to CK and CK^2 are of the right sign and significant atleast at the 10% level. This provides evidence in favor of my hypothesis in section 2 where I derived the inverted U-shaped relationship between concentration and costs of adjusting capacity (see Figure 2.8).

If we differentiate our concentration measures with respect to capacity adjustment costs (setting other variables at their mean values), and equate it to zero, we get a critical value of CK, CK^*. These critical values, representing the turning points of the inverted-U, are presented at the bottom of each column.

Referring back to the analysis of section 2, we could argue that for values of CK greater than 0.72 capacity expansion costs start becoming too large for installation of strategic capacity. Around the critical value of 0.72, capacity adjustment costs are in favor of installation of strategic capacity. Note that if such strategic behavior was not prevalent, or if strategic investment did not succeed in deterring entry, then we would not get the observed

Table 2.2
Sample Period: 1958-1972

Variable	Mean	Std. Deviation
CR4(72)	0.377	0.1834
ACR4(72)	0.389	0.1669
CK	0.76	0.18
K/L(1)	24.07	32.48
DG(1)	0.038	0.033
DV(1)	0.077	0.054

Table 2.3
Estimates: 1958-1972

	DEPENDENT VARIABLE			
	CR4(72)	LCR4(72)	ACR4(72)	LACR4(72)
Inter	0.04 (0.5)	-2.27 (-8.9)	0.07 (0.8)	-2.38 (-6.4)
CK	0.76 (2.3)	1.72 (1.8)	0.80 (2.6)	1.88 (1.8)
CK^2	-0.58 (-1.9)	-1.36 (-1.7)	-0.58 (-2.2)	-1.35 (-1.6)
K/L(1)	0.0008 (2.3)		0.0008 (1.6)	
LK/L		0.15 (4.2)		0.22 (4.9)
DG(1)	0.87 (1.7)	2.54 (2.1)	0.42 (0.9)	0.97 (0.9)
DV(1)	0.78 (2.7)	2.15 (2.4)	0.33 (1.3)	1.20 (1.4)
R^2	0.1073	0.1586	0.0861	0.2412
CK^*	0.65	0.63	0.69	0.69

Table 2.4
Sample Period: 1958-1977

Variable	Mean	Std. Deviation
ACR4(77)	0.376	0.1682
CK	0.76	0.18
K/L(2)	27.12	36.12
DG(2)	0.033	0.028
DV(2)	0.105	0.064

Table 2.5
Estimates: 1958-1977

	DEPENDENT VARIABLE	
	ACR4(77)	LACR4(77)
Inter	0.078 (0.9)	-2.49 (-0.35)
CK	0.75 (2.46)	1.72 (1.51)
CK^2	-0.52 (-1.92)	-1.18 (-1.31)
K/L(2)	0.0007 (1.57)	
LK/L		0.242 (4.7)
DG(2)	0.184 (0.34)	0.377 (0.31)
DV(2)	0.72 (0.86)	0.73 (1.86)
R^2	0.0733	0.2399
CK^*	0.72	0.73

relationship between seller concentration and capacity adjustment costs.

Contrary to the predictions of Nakao's model, the coefficient on demand growth, DG, is positive in all the equations. However, it is significant only in the first two columns of table 2.3. This provides further evidence against the traditional reasoning that demand growth will reduce seller concentration and help correct for some of the problems related to market power. In all the equations presented, the coefficient of capital-labor ratio, in level or logarithmic form, is positive and significant. The coefficients of the log-form equations show considerably larger significance levels.

The coefficient on demand volatility, DV, is always positive and generally significant. This provides evidence in favor of the risk-aversion hypothesis we summarized in section 3, that industries with high demand volatility will attract less entry and be more concentrated. Finally we note that the levels equations have pitifully low R^2s. This is in conformity with the general findings in the literature (see Curry and George (1983)). The log-form equations show considerably higher explainatory power. The two functional forms, however, are not comparable. Unfortunately the theoretical literature has little to offer regarding functional forms.

At the mean values of capital-labor ratio, demand growth, and demand volatility we get the following relationships:

$$ACR4(72) = 0.1311 + 0.80*CK - 0.58*CK^2$$

$$ACR4(77) = 0.1784 + 0.75*CK - 0.52*CK^2$$

The plots of the above relationships are shown in figures 2.10 and 2.11.

In summary we note that our empirical analysis has provided evidence in favor the hypothesis that capacity adjustment costs are an important determinant of strategic investment behavior. Evidence at the 3-digit level shows that pre-emptive behavior may be a feature of the American manufacturing sector. Finer tests, at the 4-digit level are likely to reveal more information. The lack of a consistent data base is a serious problem for analysis at a more disaggregated level. Also, at this stage, we have not been able to directly estimate adjustment costs because of problems related to computational complexity and availability of large data bases. Finally, our study does not include variables like research and development intensity and advertizing intensity. Omission of these variables may result in estimation biases and a possible reduction in the explanatory power of our estimated equations.

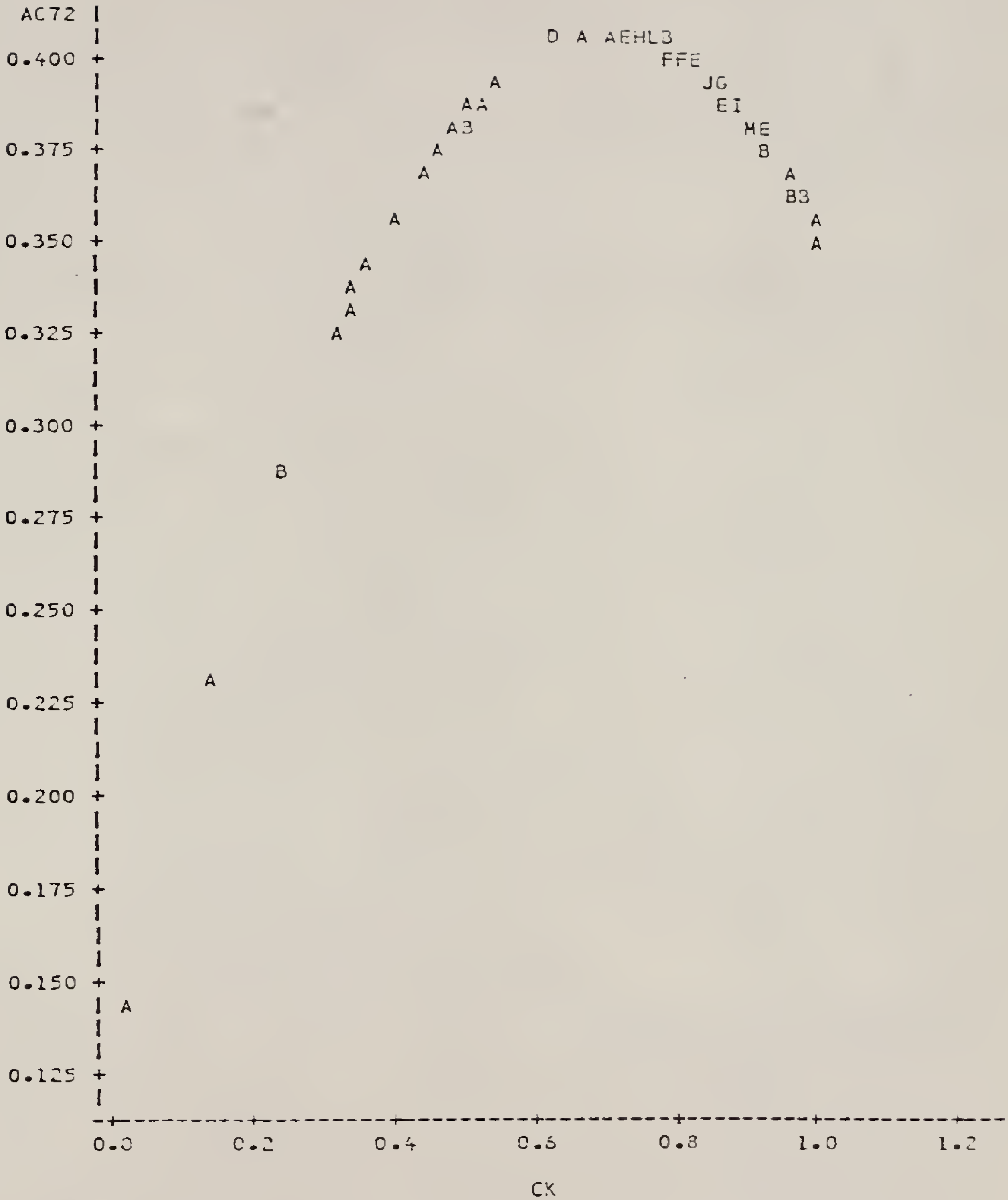

Figure 2.9: Plot of AC72*CK   Legend: A=1 obs, B=2 obs,...

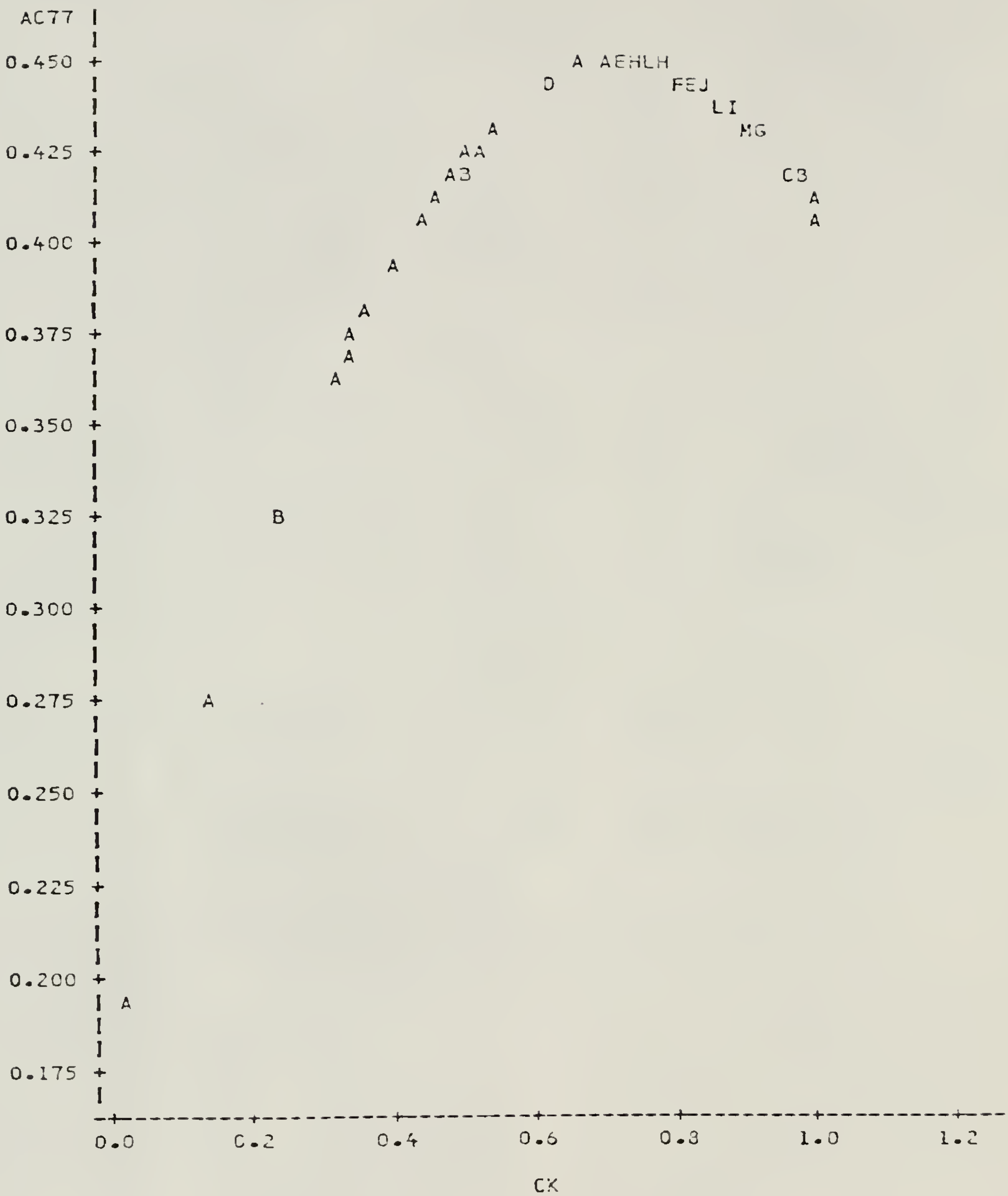

Figure 2.10: Plot of AC77*CK   Legend: A=1 obs, B=2 obs,...

CHAPTER III
INTER-INDUSTRY AND INTERTEMPORAL ANALYSIS OF PRICE-COST MARGINS

Empirical analysis of the structure-performance relationship has been one of the central issues in industrial organization since the seminal work by Bain (1951). In general, performance is measured by the markup of price over average variable cost, (P-AVC)/P, and structure is represented by the four-firm concentration ratio. Microeconomic models tell us that firms in oligopolistic, or monopolistic, markets will enjoy a greater markup as compared with firms in competitive markets. Until recently, empirical work concentrated on cross section studies to test whether more concentrated market structures lead to higher price-cost margins (PCM). Regressions of PCM on four-firm seller concentration (CR4), among other variables, showed that the coefficient of concentration was positive and significant. This evidence in turn was used by policymakers to support antitrust regulations. See Bain (1951), Collins and Preston (1969), Comanor and Wilson (1967), Domowitz et al. (1986a, 1986b), Scherer (1980, p.267-280), and Waterson (1984, cp.2 and 10) for an overview and details on the structure-performance studies.

The first study that provided evidence against the validity of the cross section results was by Qualls (1979).

Qualls highlighted the cyclical nature of PCM and that the cyclical nature differed across levels of concentration. Studies by Domowitz et al. (1986a), using a longitudinal data base covering 284 S.I.C. 4-digit industries for 24 years, showed the instability of cross sectionally estimated equations. Regressing PCM on CR4 and capital-output ratio over the period 1958-1981, they showed that the coefficient on concentration was not stable over time. There had been a steady decline in the coefficient since 1963.

The basic message of Domowitz et al. was that cross sectional inter-industry estimation of the PCM-CR4 relationship may give us misleading results. Despite the evidence presented by them one can raise three questions about their analysis. First, concentration data are published about every 5 years. No continuous time series data are available on CR4 from the census of manufactures. Domowitz et al. get over this problem by creating a time series in CR4 by interpolating. Domowitz et al. did not consider the possibility that CR4 might fluctuate cyclically. If firms in an oligopolistic industry have idle capacity and this unutilized capacity is unevenly distributed across firms, then the market shares of firms are likely to change over the course of business cycles. If idle capacity is concentrated in the larger firms, then CR4 is likely to be pro-cyclical. To the extent that CR4 is actually changing over the course

of business cycles, the results of Domowitz et al. need to be interpreted with caution.

Second, the model Domowitz et al. used to generate the results on instability is misspecified. Important variables, which were significant in other equations estimated by Domowitz et al., were omitted. In the presence of omitted variable bias, their conclusions lack credibility. Third, the traditional question in the structure-performance relationship is whether, on an <u>average</u>, more concentrated industries show higher price-cost margins. To concentrate on this traditional question in a cross section framework, we should analyze the relationship after controlling for cyclical variability. The cyclical variability of PCM and how this affects the relationship between PCM and CR4 is a different question. To analyze this question, one needs information on cyclical patterns of CR4, cyclical behavior of PCM, and whether industries show different patterns of cyclical movements in CR4 and PCM.

The aim of this chapter is twofold. First, in section 1, I shall carry out a cross section study after controlling for cyclical variability. I do this by considering 5-year sample periods, and all variables used in estimation are averages over the sample period. I estimate both linear and non-linear functional forms to test whether the relationship between concentration and profitability is monotonic or non-linear. Recently, there has been some controversy over the

effects of unionism on profitability. I examine this linkage and provide further evidence. Lastly, I address the parameter instability issue raised by Domowitz et al. (1986a) by examining both coefficient estimates as well as elasticities between CR4 and PCM.

Second, in section 2 I shall look at the intertemporal behavior of PCM. The 125 industries are classified into 7 different concentration classes to reflect their levels of competitiveness. After this I analyze time trends and volatility around trend for all the 7 classes. Finally, the rate of growth of monetary base is used as an aggregate demand influence for studying the behavior of price-cost margins over business cycles. This is in contrast to Domowitz et al. (1986a) who used the economy wide unemployment rate as an indicator of aggregate demand. Their results show that more concentrated industries experience pro-cyclical PCM. However, their results suggest counter-cyclical PCM for less concentrated industries. Qualls (1979), analyzing the volatility of PCM around a linear trend, provides evidence in favor of pro-cyclical margins.

Concentration, Profitability, and Unionism: A Non-Linear Relationship

Empirical studies that have analyzed the concentration-profitability relationship have shown that concentration is one of the important determinants of profitability. A linear relationship is postulated between

concentration and profitability. One question to ask in this context is whether the assumption of monotonicity is realistic. At the lower end of concentration, do even small changes in concentration imply larger profits? Or is it that the relationship between concentration and profitability is positive only at higher levels of concentration? I estimate both linear and non-linear functional forms to examine this issue.

Recent works by Freeman (1983) and Salinger (1984) show that there is a negative effect of unionism on profitability and that this negative effect is found mainly in more concentrated industries. Domowitz et al. (1986b), by assigning 3-digit unionism data to their component 4-digit industries, showed that the coefficient of unionism was negative and significant. However, the coefficient of the concentration-unionism interaction term was positive and insignificant. Freeman and Medoff (1979) compute unionism estimates as the percentage of total workers covered by union bargaining agreements. The data are at the 3-digit level and the percentages are averages over the years 1968, 1970, and 1972. Domowitz et al. (1986b) treat the unionism figures as a constant effect over the period 1958-1981. Here I carry out a study at the 3-digit level for two sample periods, 1968-1972 and 1973-1977, to provide further evidence on the relationship between concentration, profitability, and unionism.

To analyze inter-industry differences in PCM I constructed a data base consisting of 125 industries. Following Domowitz et al. (1986a), I computed PCM as PCM = (VS + dI - PR - CM)/(VS + dI), where VS is value of sales, dI is change in inventories, PR is payroll, and CM is cost of materials. This definition of PCM is identical to (Value Added - PR)/(Value Added + CM), given the census definition of value added. This definition is close to the markup ratio defined as (P-AVC)/P, where P is price and AVC is average variable cost. Data for all the variables were obtained from the B.I.E. data base.

As noted earlier, my two samples cover the period 1968-1977. To get some idea about time trends of price-cost margins I regressed PCM on a constant and a linear trend. There were 81 industries with a positive trend coefficient. For this group, the mean trend was 0.0034 with a standard deviation of 0.0028. The remaining 44 industries showed a negative trend coefficient. The mean trend coefficient for this group was -0.0069 with a standard deviation of 0.0228. For the 125 industries as a whole, the mean trend coefficient was -0.0002 with a standard deviation of 0.0145. To check whether there was any relationship between the level of concentration and trend, I regressed the trend coefficient on a constant and the level of concentration. The coefficient was positive (0.0018) but insignificant at standard levels

(t-statistic = 0.23). This implies that there was no difference in PCM trends across levels of concentration.

In my analysis I consider four explanatory variables: capital-output ratio (K/Q), the adjusted four-firm concentration ratio (ACR4), industry demand growth (DG), and the degree of unionization (UN). I also consider the interaction term between ACR4 and DG, and that between ACR4 and UN. The interaction terms will capture any differential effects in demand growth and unionization by levels of concentration. Finally, I use a squared concentration term to examine whether the relationship between concentration and profitability is linear or non-linear.

Annual data on gross capital stocks (K) and output (Q) were obtained from the B.I.E. data base. The four-firm adjusted concentration ratios are from Weiss and Pascoe (1986). The annual rate of growth of output was computed by continuous compounding. This was our measure of demand growth. Data on unionism, at the S.I.C. 3-digit level, are from Freeman and Medoff (1979). Since unionization data were available only for 117 industries, our sample size was reduced to the same number. I estimate three functional forms as given by equations 3.1, 3.2, and 3.3. Other than differences in levels of aggregation and methodology, equation 3.1 is similar to that estimated by Collins and Preston (1969). Equation 3.2 is a more complete specification and it includes the effects of demand growth and unionism.

Finally, in equation 3.3 I add a squared concentration term to test for non-linearities in the relationship.

$$PCM_i = \beta_0 + \beta_1 ACR4_i + \beta_2 K/Q_i + u_i \tag{3.1}$$

$$PCM_i = \alpha_0 + \alpha_1 ACR4_i + \alpha_2 K/Q_i + \alpha_3 DG_i + \alpha_4 UN_i + \alpha_5 ACR{*}DG + \alpha_6 ACR{*}UN + \epsilon_i \tag{3.2}$$

$$PCM_i = \delta_0 + \delta_1 ACR4_i + \delta_2 ACR4^2 + \delta_3 K/Q_i + \delta_4 DG_i + \delta_5 UN_i + \delta_6 ACR{*}DG + \delta_7 ACR{*}UN + v_i \tag{3.3}$$

$$i=1,2,....,117$$

The coefficient on concentration is expected to be positive. Regarding $ACR4^2$, we expect it to be non-negative. At the least we expect the relationship between concentration and profitability to be monotonic. However it is possible that the positive relationship shows up only above a certain concentration level. In this case the concentration level coefficient may be insignificant, but the coefficient attatched to the squared term will be positive and significant. Schmalensee (1987) interprets the coefficient of K/Q as the average competitive rate of return on capital plus the average annual depreciation rate, giving it a positive sign. Studies by Freeman (1983) and Salinger (1984) show that there is a negative effect of unionism on industry profitability and that this negative effect is found

primarily in more concentrated industries. Thus the coefficients of the unionism term and the concentration-unionism interaction term are expected to be negative. The effect of demand growth on PCM is not very clear. Holterman (1973) argues that there are entry and production lags. This would imply that demand growth increases the PCM of the established firms. Caves (1972) argues that the relationship between demand growth and profits might be negative because of competitive forces. In general there is no consensus on the sign of the demand growth term (see Waterson (1984, p. 197).

I constructed two samples for my analysis. <u>Sample 1</u> covers the 5-year period <u>1968-1972</u>. PCM is defined as the average PCM over the sample period and is denoted by PCM(1). The average capital-output ratio and rate of growth of output for sample 1 are K/Q(1) and DG(1), respectively. The adjusted concentration ratio for the year 1972 is ACR4(72). Unionism data are the average percentage of workers covered by collective bargaining agreements over the years 1968, 1970, and 1972. So we treat this as being constant over our sample period. <u>Sample 2</u> covers the 5-year period <u>1973-1977</u>. All variables are constructed as above. We have PCM(2), K/Q(2), DG(2), and ACR4(77) for the second sample. Concentration measure was for the year 1977 and UN data is the same as in sample 1.

Earlier we had noted the mean PCM trends for the industries in our sample. The small trend component justifies the procedure of averaging variables over our sample periods. As mentioned before, averaging of variables eliminates the cyclical components and enables us to examine the structural relationship between concentration and profitability. In terms of economic conditions, sample 1 can be considered a relatively "good" period and sample 2 a relatively "bad" period. Sample 1 represents a period when the economy was at the end of a long period of steady growth. Our second 5-year period was characterized by an economic slow down due to oil price shocks. This period was also characterized by increasing import competition, mainly from Japan. Tables 3.1 and 3.2 present some summary statistics and estimates for sample 1. The t-statistics, computed from heteroskedasticity-consistent standard errors, are in parentheses.

Examining the results in <u>column 2</u> we find the coefficients of ACR4 and K/Q(1) are positive and highly significant. This confirms the standard finding in literature. The coefficient on DG(1) is negative and insignificant at the 10% level. The coefficient on concentration-growth interaction term is positive and significant. Differentiating PCM(1) with respect to DG(1) we get dPCM(1)/dDG(1) = -0.154 + 1.096ACR. At the mean value of ACR4(72) we get dPCM(1)/dDG(1) = 0.2716. At all values of

Table 3.1
Sample Period: 1968-1972

Variable	Mean	Std. Deviation
PCM(1)	0.2689	0.0832
ACR4(72)	0.3884	0.1646
K/Q(1)	0.4917	0.3768
DG(1)	0.0184	0.0529
UN	0.4443	0.2329

Table 3.2
Estimates: 1968-1972

	DEPENDENT VARIABLE		
	PCM(1)	PCM(1)	PCM(1)
Inter	0.185 (11.63)	0.187 (7.48)	0.233 (6.47)
ACR4	0.170 (3.31)	0.243 (3.50)	-0.056 (-0.29)
$ACR4^2$			0.405 (1.80)
K/Q(1)	0.035 (1.97)	0.044 (2.51)	0.047 (2.78)
DG(1)		-0.154 (-0.68)	-0.031 (-0.31)
UN		-0.022 (-0.35)	0.004 (0.08)
ACR*DG		1.096 (1.84)	0.743 (1.10)
ACR*UN		-0.173 (-1.03)	-0.246 (-2.05)
Adj-R^2	0.1388	0.2121	0.2311
E	0.2455	0.2701	0.2353

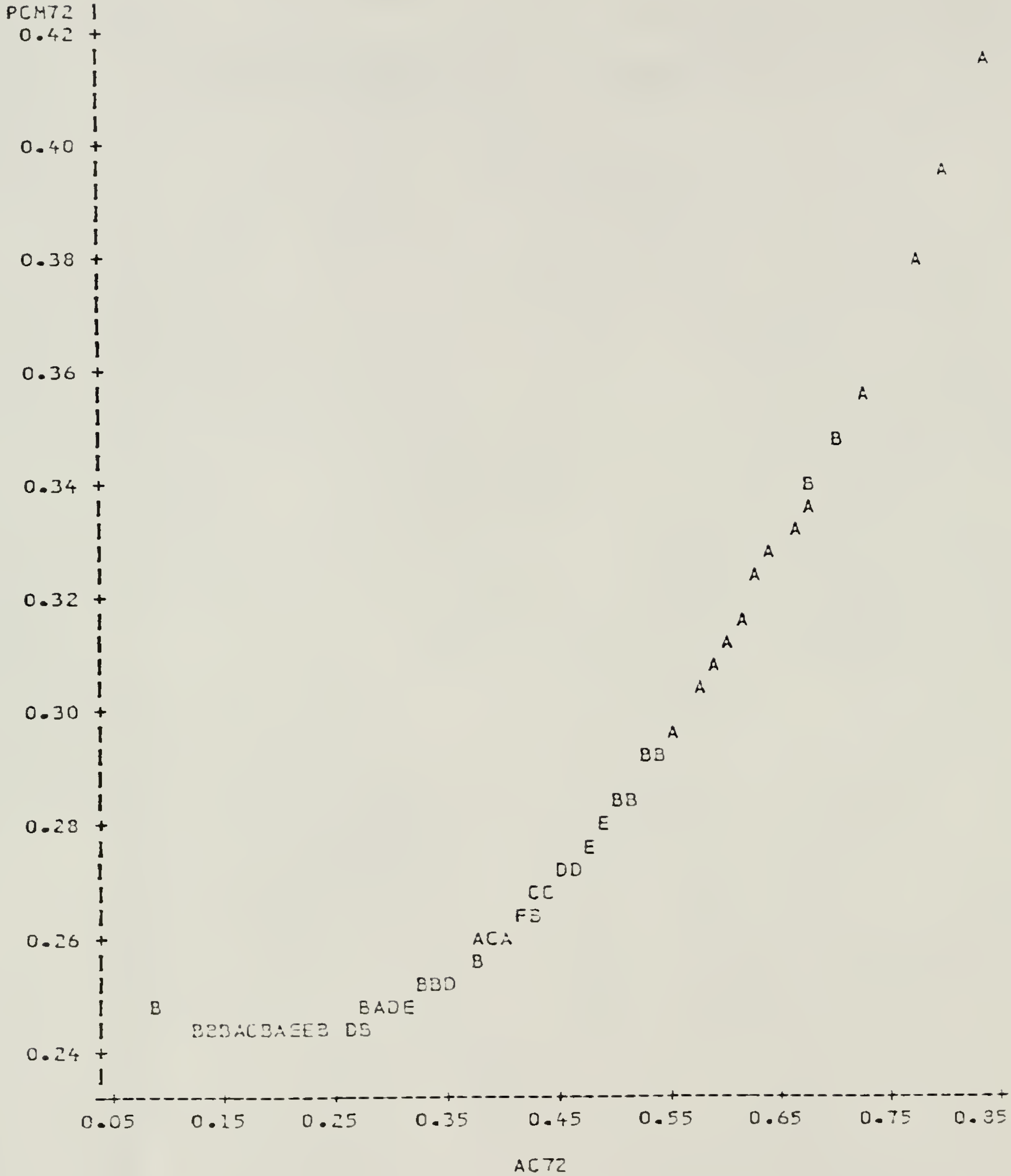

Figure 3.1: Plot of PCM72*AC72   Legend: A=1 obs, B=2 obs,...

ACR4(72) above 0.1405, dPCM(1)/dDG(1) is positive. This implies that for the majority of the industries demand growth increases profitability. The positive influence of demand growth on profitability is stronger for more concentrated industries.

The coefficient on unionism is negative as predicted, but insignificant. The coefficient on the concentration-unionism interaction term is also negative and insignificant. This implies that unionism, for this sample period, is insignificant in explaining inter-industry differences in price-cost margins. Differentiating PCM with respect to UN we get $dPCM(1)/dUN = -0.022 - 0.173ACR < 0$. This implies that across the entire range of concentration, we get a negative relationship between unionism and margins. The more concentrated the industry, the larger is the negative effect of unionism on price-cost margins. However, since the coefficients are insignificant, this provides weak evidence in favor of Freeman (1983) and Salinger (1984). Our conclusions are similar to those of Domowitz et al. (1986b).

To examine the presence of non-linearities we now turn to the results in <u>column 3</u>. The coefficient of ACR4 is negative but insignificant. However, the coefficient of squared concentration is positive and significant. This implies a significant non-linear relationship and that concentration and profitability are positively related only above a threshold concentration level. Furthermore, we note

that the introduction of $ACR4^2$ has rendered the ACR*DG coefficient insignificant. The coefficient of ACR*UN is now significant. The negative and significant coefficient of ACR*UN provides strong evidence in favor of Freeman (1983) and Salinger (1984). Finally, differentiating PCM(1) with respect to ACR4 and evaluating the derivative at the mean values of ACR4, DG, and UN we get dPCM(1)/dACR4 = 0.1629. Therefore, at mean values, the relationship between concentration and profitability is positive. Considering <u>column 3</u>, at the mean values of K/Q, DG, and UN we get $PCM(1) = 0.2572 - 0.1517ACR4 + 0.405ACR4^2$. The deravative of PCM(1) with respect to ACR4 is zero at ACR4=0.1873. So according to our estimates in table 3.2, at the mean values of K/Q, DG, and UN the relationship between concentration and profitability is negative for ACR4 less than 0.1873. If we plot the above relationship between PCM and concentration, we get figure 3.1. Over the concentration range $0 < AC72 < 0.27$ (approximately), concentration does not seem to have any positive relationship with profitability. Above AC72=0.27, however, there is a significant positive relationship. The bottom flat portion of figure 3.1 contains 31 industries, or 26.5% of the industries in our sample. In conclusion, we note that for the 1968-1972 sample there is strong evidence in favor of a non-linear relationship between concentration and profitability and that ignoring this relationship can lead to substantial omitted variable bias.

Next we carry out a similar exercise with sample 2 which covers the period 1973-1977. Table 3.3 presents the summary statistics and table 3.4 presents the estimates of equations 3.1, 3.2, and 3.3 using sample 2. As noted earlier, the unionism data are the same for the two sample periods. The t-statistics are in parentheses. All t-statistics are computed using heteroskedasticity-consistent standard errors.

Concentrating on our main interests, in column 3, we note that as before the coefficient of $ACR4^2$ is positive and significant. The coefficient of $ACR4^2$ confirms the earlier finding that concentration and profitability are positively related only at higher concentration levels. We also note that the coefficient of the concentration-unionism interaction term is significant. In comparison to column 2, the significance level dramatically improves in column 3. Strangely enough the coefficient of UN now is positive and significant. Differentiating PCM(2) with respect to UN we get $dPCM(2)/dUN = 0.076 - 0.397ACR$. Thus $dPCM(2)/dUN$ is negative over all values of ACR greater than 0.1914. The higher is concentration the more pronounced is the negative effect of unionism on profitability. However, the positive relationship between unionism and profitability at ACR4 below 0.1914 seems puzzling.

The coefficient of the ACR*DG term is positive and significant. The coefficient of DG is negative and close to

Table 3.3
Sample Period: 1973-1977

Variable	Mean	Std. Deviation
PCM(2)	0.2679	0.0995
ACR4(77)	0.3727	0.1656
K/Q(2)	0.5220	0.3875
DG(2)	0.0097	0.0404
UN	0.4443	0.2329

Table 3.4
Estimates: 1973-1977

	DEPENDENT VARIABLE		
	PCM(2)	PCM(2)	PCM(2)
Inter	0.188 (8.70)	0.167 (5.96)	0.208 (5.62)
ACR4	0.163 (2.95)	0.302 (4.37)	0.018 (0.09)
$ACR4^2$			0.401 (1.76)
K/Q(2)	0.036 (2.73)	0.046 (3.05)	0.046 (3.17)
DG(2)		-1.109 (-1.47)	-1.029 (-1.38)
UN		0.038 (0.58)	0.076 (1.50)
ACR*DG		2.970 (1.85)	2.750 (1.73)
ACR*UN		-0.295 (-1.66)	-0.397 (-3.57)
Adj-R^2	0.0851	0.1241	0.1359
E	0.2267	0.2779	0.2324

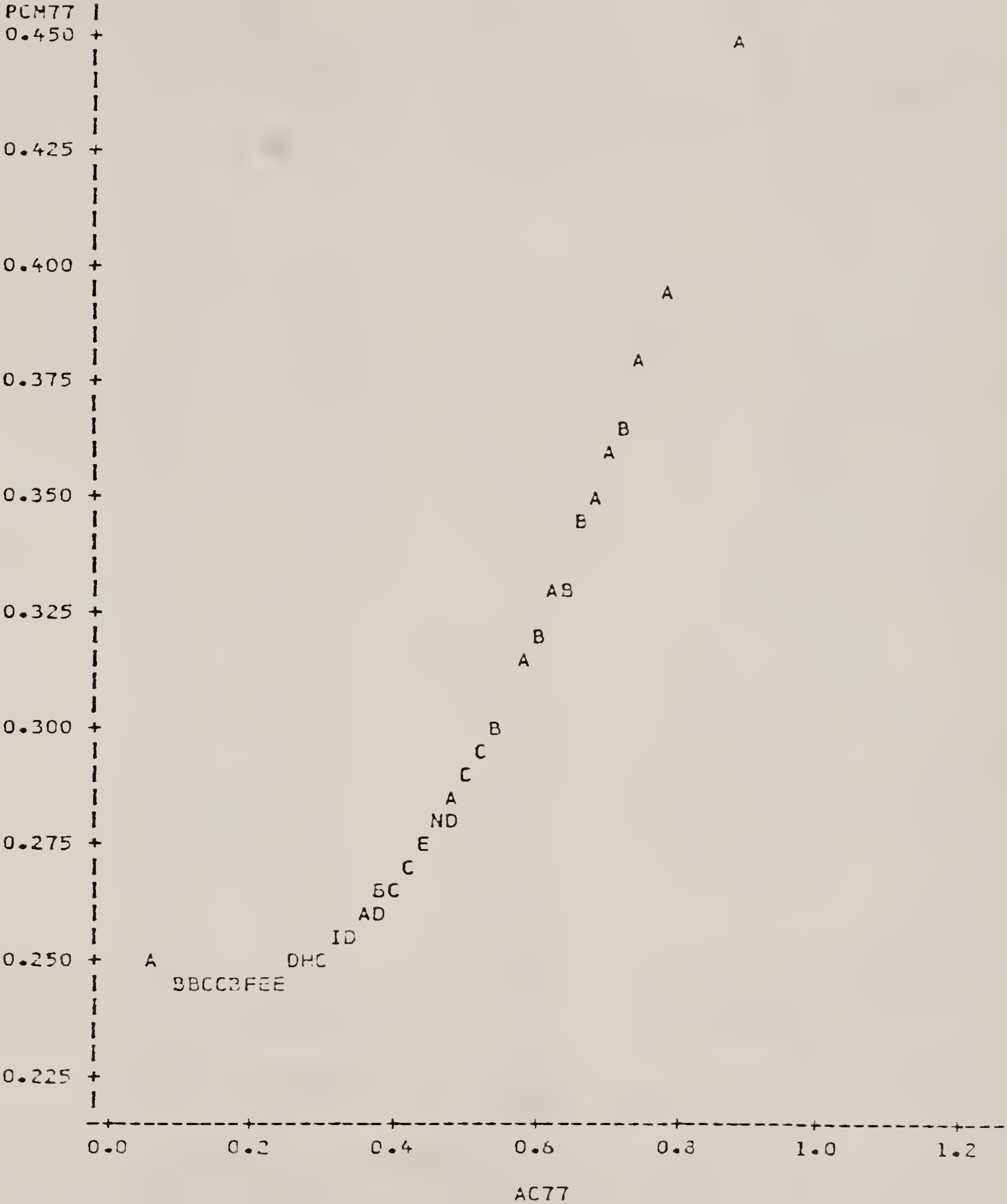

Figure 3.2: Plot of PCM77*AC77 Legend: A=1 obs, B=2 obs,...

being significant. Differentiating PCM(2) with respect to DG(2) we get dPCM(2)/dDG(2) positive for ACR4 greater than 0.3742. This indicates that more competitive industries experience a drop in PCM with demand growth. Industries that are more concentrated experience an increase in PCM with demand growth. It is difficult to make any definite conclusions on this result but it seems that the presence of non-competive forces in the more concentrated industries may be the primary factor that is driving this result. Pre-emptive behavior by dominant firms, of the kind analysed by Spence (1979) and Eaton and Lipsey (1979), would imply less entry as compared to a competitive market. This would mean that established firms enjoy larger profits in the face of growing demand. Lastly, at the mean values dPCM(2)/dACR4= 0.1672. This represents a 2.6% increase over the previous sample value of 0.1629. At the mean values of K/Q, DG, and UN we get PCM(2) = 0.2558 - 0.1317ACR4 + 0.401ACR4^2. This result is similar to the results from sample 1. As before, we plot profitability and concentration to get figure 3.2 (next page). For concentration range 0 < AC77 < 0.24, we do not observe any positive relationship. Only for AC77 > 0.24 we do observe a significant positive relationship. The bottom flat section in figure 3.2 contains 28 industries, or 24% of the industries in the sample. As in the first sample, the significance level of the ACR*UN interaction term improves considerably with the inclusion of ACR4^2. Regarding

unionism, the evidence is strongly in favor of the negative effect being found primarily in the more oligopolistic industries.

Now let us examine the issue raised by Domowitz et al. (1986a) about the instability of the concentration-profitability relationship. By looking at the results in column 1 of tables 3.2 and 3.4. we notice that the coefficient of concentration is about 4% smaller for the second sample period. This is in sharp contrast to a 33% decline in the concentration coefficient between 1972 and 1977 from the estimates of Domowitz et al. (1986a). It must be noted, however, that the DHP estimates are for the 4-digit level (compared to our 3-digit level).

Since there are interaction terms in equations 3.2 and 3.3, it will be useful to compute elasticity of PCM with respect to ACR4 at the mean values of the variables. This will give us the responsiveness of PCM to changes in concentration. To compute elasticities we differentiate PCM with respect to ACR4 and then compute elasticity at the mean values of the variables. The elasticities, E, are presented in the last row of tables 3.2 and 3.4. For the first specification we observe a 7.6% reduction in elasticity. However this is a misspecified model. For our complete specification, in the last column, we find a 1.2% reduction in the concentration elasticity of profitability. This is a small decrease and we conclude that there was structural

stability in the relationship between concentration and profitability. The main conclusions from our analysis in this section are:

(1) The presence of a significant non-linear relationship between concentration and profitability. We find the relationship to be significantly positive at higher concentration levels. Not only is this non-linearity important by itself but also on its influence on other variables, especially unionism.

(2) It is important to look at elasticities between concentration and price-cost margins. Using a complete non-linear specification we show that there is structural stability in the CR4-PCM relationship over the period 1968-1977. Also, using results from misspecified models, as in Domowitz et al. (1986a), to analyze the stability of a relationship is likely to be misleading. It is interesting to note that Domowitz et al. (1986a), in their pooled estimation, used and found interaction terms and other variables like import competition and advertizing intensity to be important. Yet they do not present annual estimates for this specification to show instability.

(3) Our results show strong evidence in favor of the negative effect of unionism (on profitability) being found mainly in the more oligopolistic industries. Furthermore, a correct non-linear specification considerably improved the significance of unionism effect.

Growth of Monetary Base and Profitability

In this section I set up a framework within which I analyze cyclical fluctuations in industry price-cost margins (PCM). I used the growth rate of the monetary base as an indicator of aggregate demand changes. The growth rate of industry output is used as a measure of local demand influence.

The empirical literature on cyclical variability of PCM is very scanty. At a disaggregated level, Domowitz et al. (1986a), Qualls (1979), and Schmalensee (1987) are probably the only rigorous works in this area. Domowitz et al. use the contemporaneous economy wide unemployment rate as their indicator of aggregate demand conditions. The Domowitz et al. study covers 284 4-digit industries over the period 1958-1981. Their results are somewhat intriguing. Their estimated coefficients suggest counter-cyclical PCM at low levels of concentration. As the level of concentration rises, PCM becomes pro-cyclical. While the latter result is expected, the former result needs explaination. Schmalensee (1987) concludes that both unemployment and GNP were less useful in analyzing cyclical variability of PCM than capacity utilization rate. Qualls (1979) summarizes the basic theoretical issues related to oligopolistic coordination and price fluctuations and provides empirical evidence on these issues. Qualls' main finding is that there is a positive relationship between PCM fluctuations and concentration.

Qualls' study also shows that relative to trend value, PCM is compressed more in recessions and expand more in expansions for highly concentrated industries. Qualls uses a data base covering 79 4-digit industries over the period 1958-1970.

I develop a framework where 3-digit industries are classified into 7 concentration classes. The concentration range and classification are shown in table 3.5.

Table 3.5
Concentration Classification

Concentration Range	Classification
$0 \leq ACR4 \leq 20$	C1
$21 \leq ACR4 \leq 30$	C2
$31 \leq ACR4 \leq 40$	C3
$41 \leq ACR4 \leq 50$	C4
$51 \leq ACR4 \leq 60$	C5
$61 \leq ACR4 \leq 70$	C6
$71 \leq ACR4 \leq 100$	C7

The Weiss-Pascoe adjusted concentration ratios are denoted by ACR4. We use broader concentration range for C1 and C7 because there were very few industries in the concentration range below 10 and above 80. The mean values of the 1972 and 1977 concentration ratios were used to categorize the industries. The classes are in decreasing order of competitiveness. The most competitive group is C1 and C7 is the least competitive group. All of our experiments were based on analyzing the mean PCM of each group. The analysis

of price fluctuations in oligopolistic markets has focussed on the role of interfirm information flows, threat of retaliation, and uncertainty. Bain (1950) argued that high concentration would lead to better interfirm information flows and this would be conducive to collusion. These information flows would facilitate the maintanence of a larger price markup above costs. Qualls (1979) argued that these same information flows will allow firms to vary the markup over business cycles without a breakdown of interfirm coordination. In short, this line of reasoning implies that highly concentrated industries would succeed in maintaining higher markups and that these markups will be pro-cyclical.

Industries with moderate to low concentration, or weak oligopolies, are expected to face problems of interfirm coordination. Increase in the number of decision making firms, incomplete information flows, and uncertainty about rivals' actions have been argued to have a stabilizing effect on prices. Stable prices in turn would imply stable PCM over business cycles.

In a purely competitive market, prices will fall along the short run marginal cost schedule when demand falls. During an expansion, prices will rise along the marginal cost schedule. This implies volatility of prices and PCM over business cycles.

Summarizing the arguments from the existing literature we get prices and PCM being pro-cyclical in both

perfectly competitive and highly concentrated industries (this, however, precludes entry and exit for short run changes in demand). Prices and PCM are likely to be more stable for market structures characterized by low to moderate concentration. If we observe the complete spectrum of market structures, perfect competition to monopoly, then the relationship between PCM volatility and concentration would be U-shaped. However, if we do not observe perfectly competitive markets then the relationship will be positive. It has been argued that the degree of atomism required for perfectly competitive markets may not exist. As we have already noted, Qualls found the relationship between PCM volatility and concentration to be positive.

Since our primary aim was to study PCM movements over business cycles, we analyzed PCM movements after detrending. We denote the price-cost margins for our 7 classes by PCMC1 to PCMC7. The time trends and volatility around trend of each group is presented in table 3.6. The t-statistics are in parentheses. The volatility of PCM is measured by the root mean square error (RMSE) from the regression of PCM on a constant and linear trend.

The correlation between concentration class and time trend is 0.302 but insignificant at the 10% level. This implies that there are no significant differences in time trends across levels of concentration. The correlation between RMSE and concentration class is 0.798 and is

significant at the 5% level. For classes 1 to 4 there seems to be no relationship between RMSE and concentration class. RMSE is significantly greater for classes 5 to 7. This is in conformity with Qualls' findings that more concentrated industries show greater PCM volatility.

Table 3.6
PCM Time Trends

Dep Var	Inter	Time	Adj R^2	RMSE
PCMC1	0.186 (67.8)	0.0025 (12.5)	0.8765	0.0063
PCMC2	0.214 (85.8)	0.0020 (11.3)	0.8533	0.0057
PCMC3	0.229 (63.7)	0.0029 (11.8)	0.8793	0.0063
PCMC4	0.241 (92.0)	0.0014 (7.38)	0.7090	0.0061
PCMC5	0.268 (74.8)	0.0028 (11.0)	0.8452	0.0083
PCMC6	0.261 (67.7)	0.0022 (7.7)	0.7265	0.0089
PCMC7	0.312 (45.4)	0.0032 (6.4)	0.6452	0.0159

To return to our main analysis, we need a variable that can be used as an aggregate demand influence. We used a monetary aggregate, the rate of growth of monetary base (DBASE). See Barro (1987, cp. 15) and Rush (1986) for details on the use of monetary base as a demand influence.

Increase in rate of growth of monetary base will, via the multiplier effect, stimulate aggregate demand. Decrease in rate of growth will deflate demand. Monetary base is defined as currency in circulation plus the reserves held by the financial intermediaries at the FED. The FED uses open market operations as the principal instrument for controlling monetary base. Regarding neutrality of money, a one time shift in the monetary base will induce proportional response in wages, prices, and all nominal variables. This will leave real variables like quantity of output and employment unchanged.

If all nominal variables adjust instantaneously then even in the short run there will be no real effects. However, Fischer (1977) and Phelps and Taylor (1977) have shown that wage contracting results in nonneutrality. Mishkin (1982) provides evidence that even anticipated changes in money matter. In general, the short run effects of money growth will depend on the nature of wage and price flexibility.

The nature of wage price flexibility is crucial to our analysis. Assuming that labor is the only variable factor of production, we define PCM as $(P*Q - w*L)/P*Q$. Where P is price, Q is output, w is wage rate, and L is employment. Dividing by Q and simplifying we get $PCM = 1 - (w/P)*(L/Q)$. Let us assume for the moment that L/Q is constant. If wages are sticky due to contracting and if prices are flexible then in the short run money growth will increase P, reduce

w/P, and increase PCM. If both w and P adjust instantly then PCM will not change because w/P will stay constant. More generally, the effect of money growth on PCM will depend on the relative flexibility of wages and prices and on the ratio L/Q (what happens to L/Q will depend on the nature of the production function). If prices are relatively more flexible than wages then money growth will, in the short run, increase PCM (assuming L/Q is constant). If we include materials as a variable factor of production we get $PCM = 1 - (w/P)*(L/Q) - (c/P)*(M/Q)$. Where c is per unit materials cost and M is total materials used. Here again the results depend on the relative flexibility of c versus P. If producers obtain materials via prearranged contracts leading to sticky short run c, then money growth will increase P and increase PCM. The net effect will depend on the relative flexibility of wages, prices, and materials costs. If wages and/or materials costs are relatively inflexible compared to prices then money growth will increase PCM in the short run.

From our earlier discussion of price flexibility, and from the results of Qualls, we noted that prices are likely to be strongly pro-cyclical in more concentrated industries. In low to moderately concentrated industries, due to lack of interfirm information flows, prices would tend to be more stable over business cycles. Linking this up with money growth, an expansion of money base will lead to a stronger price response in more concentrated industries. If wages are

sticky in the short run and assuming that the degree of stickiness is even across levels of concentration, growth of money base will lead to stronger PCM response in more concentrated industries. In general we should observe a positive short run relationship between concentration and the responsiveness of PCM to growth of base money. Since there are lags between expansion of money base and its effects on the economy, both current and lags of money growth will be important in determining current PCM. Finally, if there is entry in anticipation of demand growth then the effects on price and PCM will be small. However, if we preclude entry to short run changes in demand then our above analysis will go through.

Summarizing, our prediction of the effects of money growth on PCM is twofold: (i) there is a positive relationship between money growth and PCM and (ii) the relationship between money growth and PCM is stronger for more concentrated industries. In terms of our concentration classes, we expect the higher classes to show greater responsiveness to growth of money base. To get evidence on the above hypothesis we estimate equation 3.4.

$$PCMC(i)_t = \alpha_0 + \alpha_1 T + \alpha_2 DQC(i)_t + \alpha_3 DBASE_t + \alpha_4 DBASE_{t-1} + \epsilon_t \qquad (3.4)$$

Where PCMC(i) is the mean PCM of the industries in the i^{th} class. The mean rate of growth of output is denoted by DQC(i). Growth rate of money base is denoted by DBASE. Data on base money are from Rush (1986). Industry PCM and demand growth are as constructed in the previous section. Data on industry variables were obtained fron the B.I.E. data base. Since we are interested in analyzing the cyclical nature of PCM, we include a time trend to capture the deterministic components.

Regarding sign predictions, we expect both α_3 and α_4 to be positive. Also, we predict the total effect of growth of base money on PCM to increase over concentration levels. The total effect is measured by $\alpha_3 + \alpha_4$. We expect this sum to increase over the concentration classes. From discussions in the previous section, the sign of α_2 is ambiguous. Because our data base is for a relatively short time period, we did not experiment with longer lags of DBASE. The results of estimating equation are presented in table 3.7. The t-statistics are in parentheses.

First, we note that DASE stands for lagged DBASE. Our first observation is that all coefficients on the money growth variables, other than DBASE1 for PCMC1, are positive as predicted. A majority of them are significant atleast at the 10% level. Regarding industry demand growth, all coefficients, other than PCMC1, are positive. They are significant only for PCMC3, PCMC4, and PCMC7. The time trend

coefficients are positive for all and, except for PCMC7, significant at standard levels. The Durbin_watson statistics (DW) in general lie in the inconclusive range. Since we

Table 3.7
Cyclical Determinants of PCM

	PCMC1	PCMC2	PCMC3	PCMC4	PCMC5	PCMC6	PCMC7
Inter	0.185 (52)	0.212 (74)	0.222 (91)	0.237 (127)	0.265 (78)	0.256 (60)	0.308 (42)
T	0.002 (5.3)	0.001 (4.6)	0.002 (9.3)	0.001 (3.3)	0.002 (5.2)	0.001 (2.2)	0.001 (1.6)
DQ	-0.027 (-0.8)	0.033 (1.4)	0.054 (2.4)	0.058 (3.8)	0.037 (1.3)	0.023 (0.5)	0.084 (2.0)
DBASE	0.139 (1.8)	0.093 (1.6)	0.141 (2.8)	0.104 (2.4)	0.202 (2.7)	0.131 (1.1)	0.010 (0.1)
DBASE1	-0.019 (-0.2)	0.123 (1.9)	0.144 (3.0)	0.141 (3.4)	0.119 (1.6)	0.223 (2.1)	0.537 (3.1)
Adj R^2	0.846	0.875	0.957	0.901	0.907	0.789	0.711
DW	1.179	1.369	1.440	1.955	1.358	1.215	1.721

cannot decisively reject the null hypothesis of zero autocorrelation, we do not resort to any mechanical corrections.

Table 3.8 presents the mean values for price-cost margins and growth of monetary base. In table 3.9 we present the sum of the coefficients attatched to DBASE and DBASE1. We denote this by β ($\beta=\alpha_3+\alpha_4$). Table 3.9 also presents the elasticities (E) between PCM and DBASE, at the mean values.

Table 3.8
Mean Values of PCM

Variable	Mean	Std. Deviation
PCMC1	0.2163	0.018
PCMC2	0.2393	0.015
PCMC3	0.2631	0.021
PCMC4	0.2586	0.011
PCMC5	0.3034	0.021
PCMC6	0.2873	0.017
PCMC7	0.3507	0.026
DBASE	0.0508	0.028

Table 3.9
Effect of Money Growth on PCM by Concentration Class

	CLASS						
	C1	C2	C3	C4	C5	C6	C7
β	0.120	0.216	0.285	0.245	0.321	0.354	0.547
E	0.028	0.046	0.055	0.048	0.054	0.063	0.079

The correlation between the β coefficients and class is 0.92 and is significant at the 1% level. The correlation between the elasticity, E, and class is 0.912 and is significant at the 1% level. Our analysis provides strong evidence in favor of the hypothesis that base money growth and PCM are positively related and that the relationship is stronger for highly concentrated industries.

Our analysis provides evidence that price-cost margins are pro-cyclical across all levels of concentration. Also, more concentrated industries show stronger pro-cyclical margins. At the lower concentration levels our results are in

direct contrast to the results of Domowitz et al. (1986a), which suggest counter-cyclical margins for less concentrated industries. Finally, in concluding we note that a larger time series data base is likely to provide more information on the relationship between business cycles and price-cost margins. That would enable us to look at both supply side and demand side effects and consider longer lags of money growth.

CHAPTER IV
CONCLUSIONS

The role of investment as an entry deterring instrument has received an increasing amount of theoretical attention. We set out to analyze the implications of firm behavior on seller concentration, within the broad framework of these models. We relaxed a rather stringent assumption that is common in the existing models, namely that of no downward adjustment and instantaneous upward adjustment of capacity. By assuming that firms can adjust capacity both upwards and downwards, subject to quadratic and symmetric adjustment costs, we were able to analyze the issues related to the credibility and desirability of strategic capacity. From this we derived an inverted U-shaped relationship between seller concentration and adjustment costs of capital. Using speed of adjustment as a proxy for cost of adjustment, our empirical results provided evidence in favor of our hypothesis. The encouraging nature of the results suggests useful extension to the 4-digit level.

Our analysis indicates a possible extension. In the Stackelberg post-entry case, Dixit (1979), Spence (1977), and Spulber (1981), results show that the incumbent firm maintains a threat of expanding output in the face of entry. For this the firm will have to hire labor and incur costs of adjusting labor. So, in a Stackelberg game one could analyze

the relationship between labor adjustment costs and strategic behavior. One could also look at the possibility of firms holding excess stocks of labor. This would make the analysis symmetric in both labor and capital.

From the theoretical works it is clear that strategic investment can be an important form of pre-emptive behavior. Thus it is necessary to incorporate strategic investment behavior as an endogenous variable in the study of industrial structure. One could try to quantify such behavior by looking at the presence and persistence of idle capacity. However idle capacity may also exist for other reasons. For example, firms may invest in capacity in anticipation of demand growth. In general it would be difficult to separate out the strategic and non-strategic components of capacity. Moreover, if firms are playing a Cournot-Nash game, as in Dixit (1980), then no idle capacity will be held, implying that we cannot identify strategic capacity by looking at idle capacity. In such cases pre-emptive investments will be hard to detect. To the extent that strategic investment can be quantified, it can be incorporated in the study of industry characteristics.

Our analysis in section 1 of chapter III shows that with proper model specification and controlling for cyclical variability, one can carry out cross section analysis in the area of concentration-profitability relationship. While Domowitz et al. (1986a) show that cross section analysis

gives us misleading results, they do so by using a misspecified model. At the 3-digit level, by using averages of variables over small time periods, and by using a correct non-linear specification, we show remarkable stability in the elasticity between concentration and profitability. This implies that cross section analysis is a legitimate way to analyse the structure-conduct-performance paradigm.

Lastly we used the growth rate of the monetary base to examine the cyclical nature of price-cost margins. Our findings show that margins are strongly pro-cyclical in more oligopolistic industries.

Regarding implications for antitrust policy, our analysis in section 1 of chapter 3 is of importance. If, through proper non-linear model specification, we can identify a threshold concentration level then this could be used to formulate antitrust policy. Movements to higher concentration levels below this threshold level would not imply significant increase in market power. But a movement to a concentration level beyond the threshold level would imply significant increase in market power. Beyond the threshold concentration level, industries should be subject to scrutiny for possible entry deterring and other anti-competitive behavior.

APPENDIX A
DIRECT ESTIMATION OF ADJUSTMENT COSTS

Sargent (1978) outlined a methodology by which we can directly obtain estimates of adjustment costs of factors of production. Sargent estimated adjustment costs for straight-time labor (STL) and overtime labor (OTL) for the American manufacturing sector as a whole. He found that it was 23 times more expensive to adjust STL as compared to OTL. Also, Sargent's results showed that the data rejects the rational-expectations hypothesis. Our main objective is to determine the viability of this technique for estimating adjustment costs at a more disaggregated level. Also, it is of interest here to see whether the rational-expectations hypothesis finds any support at a more disaggregated level. We reduce the computational complexity of Sargent's model by assuming the wage process to be AR(2). Also, we use a more reasonable estimate of average weekly overtime hours per week.

Sargent's model is a basic labor demand model where employment depends inversely on real wage. A dynamic structure is incorporated into the above relationship by assuming that firms face costs of adjusting labor. So, the firms find it optimal to take into account expected future values of the real wage process in determining their current employment level. Since firms use the moments of the real

wage process in their decision making, the rational-expectations hypothesis is imposed on the model.

A typical firm faces stochastic and quadratic production functions for STL and OTL as given by equations A.1 and A.2, respectively. Capital stock is assumed to be a constant, K.

$$g_1(n_{1t},K) = (f_0+a_{1t})n_{1t} - (f_1/2)n_{1t} \qquad (A.1)$$

$$g_2(n_{2t},K) = (f_0+a_{2t})n_{2t} - (f_1/2)n_{2t} \qquad (A.2)$$

Where f_0, $f_1 > 0$ are firm specific parameters. The stochastic processes a_{1t} and a_{2t} affect the productivity of STL and OTL respectively. The firm can hire STL at real wage w and OTL at real wage pw, where p (=1.5) is the overtime premium. The adjustment cost functions for STL and OTL are $(d/2)(n_{1t}-n_{1t-1})^2$ and $(e/2)(n_{2t}-n_{2t-1})^2$, respectively. Where d and e are the adjustment cost parameters. The stochastic processes for a_{1t} and a_{2t} are:

$$a_{1t} = p_1 a_{1t-1} + e_{1t}$$

$$a_{2t} = p_2 a_{2t-1} + e_{2t}$$

For computational simplicity we assume that the wage process is AR(2) and is given by:

$$w_t = v_0 + v_1 w_{t-1} + v_2 w_{t-2} + e_{3t}$$

Given these, the firm at time t chooses n_{1t} and n_{2t} to

maximize its real present value (PV) given by equation A.3.

$$PV = E_t \Sigma_j b^j \{ (f_0+a_{1t+j}-w_{t+j})h_1n_{1t+j} - (f_1/2)h_1n_{1t+j}{}^2$$
$$- (d/2)(n_{1t+j}-n_{1t+j-1})^2 + (f_0+a_{2t+j}-1.5w_{t+j})h_2n_{2t+j}$$
$$- (f_1/2)h_2n_{2t+j}{}^2 - (e/2)(n_{2t+j}-n_{2t+j-1})^2 \} \qquad (A.3)$$

Where b (=0.95) is the real discount rate. By assuming the wage process to be AR(2) we get a three variate vector autoregression given by the equation system A.4-A.6. (see Sargent for the complete general specification).

$$n_{1t} = (\delta_1+p_1)n_{1t-1} - \delta_1p_1n_{1t-2} + (\alpha_2+\alpha_1v_1-\alpha_1p_1)w_{t-1} +$$
$$(\alpha_1v_2-\alpha_2p_1)w_{t-2} + u_{1t} \qquad (A.4)$$

$$n_{2t} = (\phi_1+p_1)n_{2t-1} - \phi_1p_2n_{2t-2} + (\beta_2+\beta_1v_1-\beta_1p_2)w_{t-1} +$$
$$(\beta_1v_2-\beta_2p_2)w_{t-2} + u_{2t} \qquad (A.5)$$

$$w_t = v_1w_{t-1} + v_2w_{t-2} + u_{3t} \qquad (A.6)$$

Since we restricted the wage process to be AR(2), we can explicitly evaluate the constraints. From the constraints we get:

$$\delta_1 = \{ (37f_1/d + 1.95) - (37f_1/d + 1.95)^2 - 3.61)^{1/2} \}/1.9$$
$$\phi_1 = \{ (7f_1/e + 1.95) - ((7f_1/e + 1.95)^2 - 3.61)_{1/2} \}/1.9$$
$$\alpha_1 = -\delta_1h/d(1 - 0.95v_1\delta_1 - 0.90v_2\delta_1{}^2)$$
$$\alpha_2 = 0.95v_2\delta_1\alpha_1$$

$\beta_1 = -10.5\phi_1/e(1 - 0.95v_1\phi_1 - 0.90v_2\phi_1^2)$

$\beta_2 = 0.95v_2\phi_1\beta_1$

We estimate the above model with the method of maximum likelihood. The equation system has 10 regressors and 7 free parameters (f_1, d, e, p_1, p_2, v_1, and v_2). We assume that the error vector is trivariate normal. Following Bard (1974) and Wilson (1973) we write the logarithm of the likelihood function as:

$$\text{Log } L(\Theta) = -(1/2)mT\text{Log}(2\pi) - (1/2)T\{\text{Log}|V\text{-hat}| + m\}$$

Where m is the number of variables in the model and T is the number of observations. Maximum likelihood estimates of the free parameters are obtained by minimizing |V-hat| (the determinant of the estimated covariance matrix) with respect to the set of free parameters.

We first estimate an unconstrained model to obtain unrestricted log-likelihood, $\text{LogL}(\Theta)_{ur}$. Next, we estimate the model subject to the constraints (see Sargent for details) to obtain the restricted log-likelihood, $\text{LogL}(\Theta)_r$. We have 10 regressors and 7 free parameters. So $-2\{\text{LogL}(\Theta)_r - \text{LogL}(\Theta)_{ur}\}$ is distributed as chi-square with 3 degrees of freedom. High values of the likelihood ratio lead to the rejection of the restrictions the theory imposes on the vector autoregression.

Data for estimation were obtained from the Bureau of Labor Statistics (BLS). Our sample period was from 1965:1 to 1981:2. The series on n_{1t} was obtained from seasonally adjusted BLS series on employees on non-agricultural payroll.

Wage data were obtained from the hourly earnings series. The nominal wage series was deflated by CPI (1967=100) to obtain the real wage series. Following Sargent, the series on n_{2t} was constructed using the following formula:

$$n_{2t} = ((H_t - h_1)/h_2)n_{1t}$$

Where H_t is the seasonally adjusted average weekly hours series. Average weekly straight-time hours, h_1, is estimated at 37. Sargent assumes that average weekly overtime hours per week, h_2, is 17. Since this estimate seems to be unreasonable, we use a more reasonable h_2=7. All data used for estimation, n_{1t}, n_{2t}, and w_t were detrended by regressing them on a constant, trend, and trend squared. The residuals from this regression were used as data. Detrending is done to isolate the indeterministic components and to account for changes in the capital stock.

To obtain the estimates of the free parameters of the model I used the Powell (1968) method of numerical optimization. This procedure does not rely on computing derivatives to locate the optimum. Gradient based methods available in standard econometric packages like SAS and TSP failed to yield any results, the main problem being related to convergence. Table A.1 presents the constrained parameter estimates for the model defined by equations A.4-A.6. Below the parameter estimates we report the likelihood ratio LR

(obtained from the restricted and unrestricted log-likelihood), the marginal confidence level MCL, and the ratio of straight-time to overtime adjustment costs d/e.

Table A.1
Industry Estimates

Parm	INDUSTRY Non-Elec. Machinery	Fab. Metal	Pmy. Metal	Wood & Lumber	Elect. & Electronics
f_1	0.98	2.74	3.89	4.19	9.54
d	264.5	540.5	180.6	160.9	337.3
e	43.07	153.0	24.14	82.08	168.19
p_1	0.71	0.68	0.41	0.69	0.83
p_2	0.21	-0.05	0.37	0.39	0.38
v_1	0.86	0.84	0.86	0.93	1.08
v_2	-0.17	-0.13	-0.25	-0.18	-0.26
LR	126.8	30.66	1.94	19.76	16.58
MCL	0.99	0.99	0.45	0.99	0.99
d/e	6.14	3.53	7.48	1.96	2.0

From the results we can see that other than Primary metals, the rational-expectations hypothesis is rejected for all industries. The high marginal confidence level indicates that the data contain substantial evidence against the hypothesis. The ratio of straight-time to overtime adjustment cost varies between 1.96 for Lumber to 7.48 for Primary Metals. These estimates are significantly different from

Sargent's estimate of 23 for the manufacturing sector as a whole. Due to the complicated nature of the model we did not compute any standard errors.

Regarding the use of such estimation procedures for computing adjustment costs at a more disaggregated level we note three points:

(1) The optimizing procedures require that we provide starting values for the parameters. Also, different starting values are necessary as a check for multiple minima. Our experiments revealed that the final estimates, specially for the adjustment cost parameters d and e, were extremely sensitive to the choice of starting values. Wide fluctuations in final estimates were observed corresponding to different starting values. This clearly implies that the parameter estimates are unreliable.

(2) Numerical optimization procedures are computationally expensive. The number of iterations to convergence is quite large. This implies that this procedure cannot be used for a highly disaggregated study like the one in chapter 2.

(3) Sargent (1978) reports that certain diagonal elements of the covariance matix of estimates turned out to be negative. This casts further doubts on the use of such techniques for estimation.

APPENDIX B
DEMAND UNCERTAINTY AND FACTOR INTENSITY

During the 1970's a series of articles in the American Economic Review analyzed the influence of demand uncertainty on firm behavior. Hartman (1976), Holthausen (1976), Leland (1972), and Sandmo (1971), among others, looked at the issues related to firm profitability and input choices under the assumptions of risk-aversion and risk-neutrality in the presence of demand uncertainty. One of the results that emerged from this analysis was that risk-averse firms will use more labor to produce any given level of output and hence will use a lower capital-labor ratio (K/L). A risk-neutral firm will operate at the efficient K/L. However, under the hypothesis of decreasing absolute risk-aversion, the risk-averse firm's K/L will increase as its size increases. Therefore the larger the risk averse firm becomes, the closer it will operate to the efficient K/L.

From this line of reasoning we can see that K/L is not determined by technology alone, as is commonly assumed. Assuming risk-aversion, K/L will depend on demand uncertainty (inversely), firm size (directly), and technology. Furthermore, from the analysis of Spence (1979) and Eaton and Lipsey (1979), we can see that firms might install capacity in anticipation of demand growth. To control for this factor we need to include demand growth as an explanatory variable.

We expect K/L to be positively related to demand growth.

$$K/L = f(\underset{-}{DU} : \underset{+}{SIZE} : \underset{+}{DG} : TECH)$$

Where DU is demand uncertainty, SIZE is a measure of firm size, DG is demand growth, and TECH is technology. Since we do not have any measure of technology that is independent of K/L, we drop TECH as an explainatory variable.

We use data on 125 S.I.C. 3-digit manufacturing industries to test the above relationship. As a measure of SIZE we use the four-firm concentration ratios (ACR4) from Weiss and Pascoe (1986). Our sample period is 1958-1977. ACR4 is for the year 1977. The measure of demand uncertainty is constructed from the following regression:

$$LogQ_t = \alpha_0 + \alpha_1 t + u_t$$

Where LogQ is the logarithm of output and t is time. We use the standard error of residuals from the above regression as our measure of demand uncertainty and denote it by DV. Demand growth is the rate of growth of output over the sample period. Annual data on gross capital stocks (K), production workers (L), and output (Q) were obtained from the B.I.E. data base. K/L is the mean K/L over the period 1958-1977. Since the theory does not provide us with any functional form, we estimate a levels equation. Results are reported in

the following equation. Heteroskedasticity-consistent t-statistics are in parentheses.

$$K/L = \underset{(2.7)}{17.06} + \underset{(2.4)}{37.63}ACR4 - \underset{(-1.88)}{74.92}DV + \underset{(1.68)}{113.73}DG$$

All variables have the predicted signs and are significant. To carry out another experiment we use a shorter sample period, 1973-1977. For this sample we define demand uncertainty as the coefficient of variation of output (CVQ). K/L is the mean K/L over the 5-year period and DG is now the rate of growth of output over the 5-year period. Concentration measure is for the year 1977. The estimated equation for this smaller sample period is:

$$K/L = \underset{(1.2)}{11.27} + \underset{(3.25)}{59.01}ACR4 - \underset{(-0.1)}{0.06}CVQ + \underset{(1.6)}{186.71}DG$$

As in the previous case we get the expected signs but the coefficient of variation is insignificant. We must, however, note that the measure of uncertainty is constructed differently in the second case. The only consistent result coming out of the two equations is that K/L and concentration, and K/L and demand growth are positively related. Our results suggest a simultaneous determination of concentration and K/L.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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